SAE Journal

MARCH 1957

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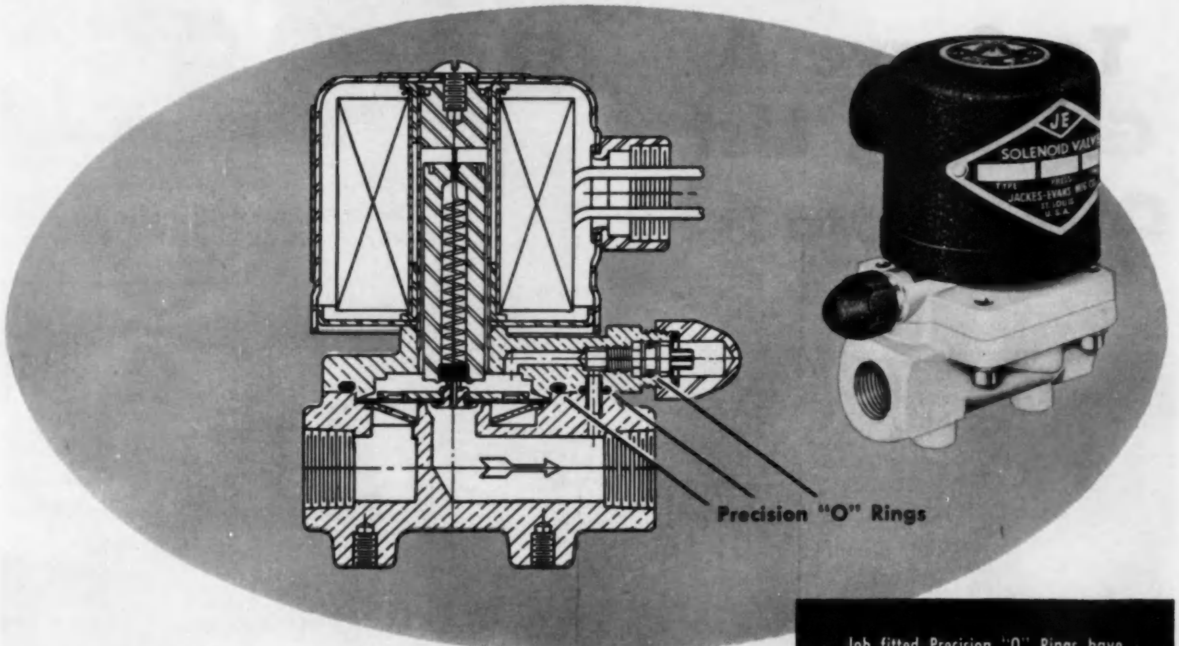

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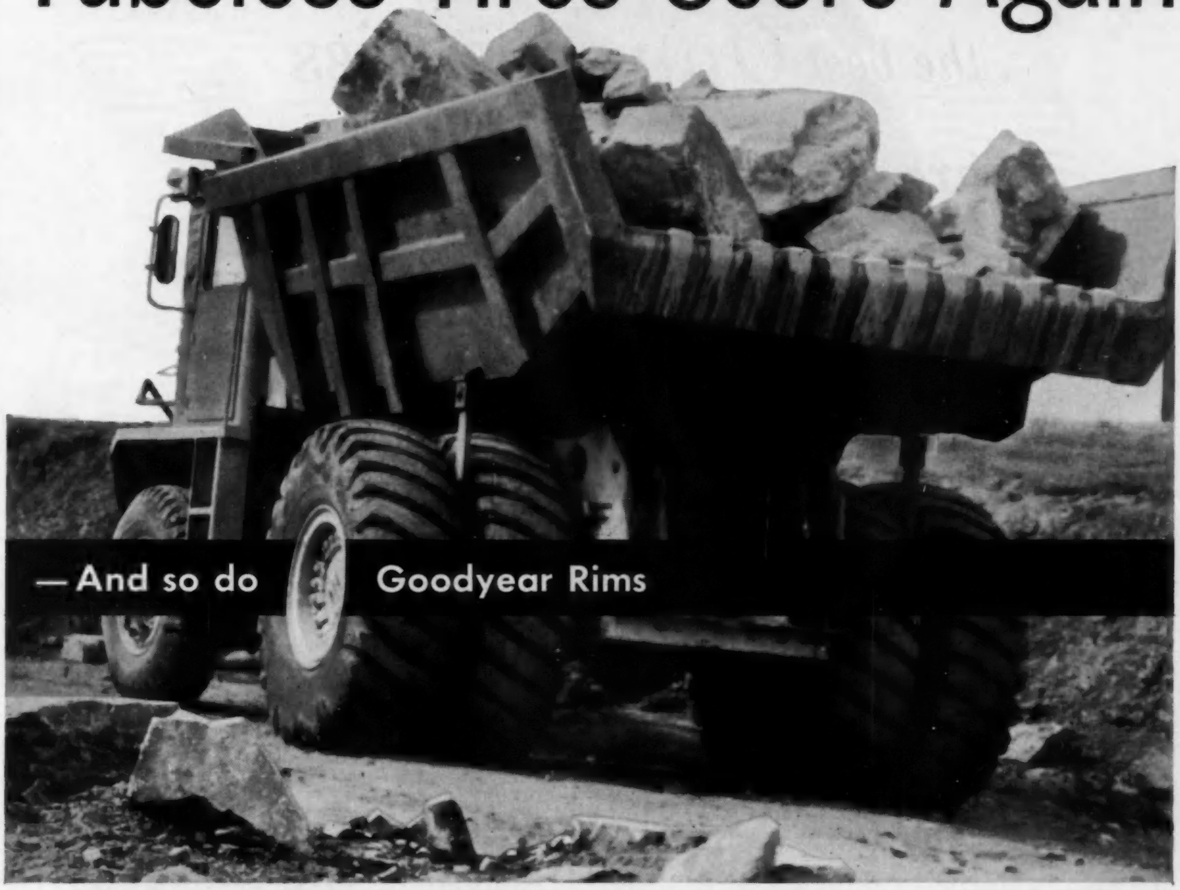

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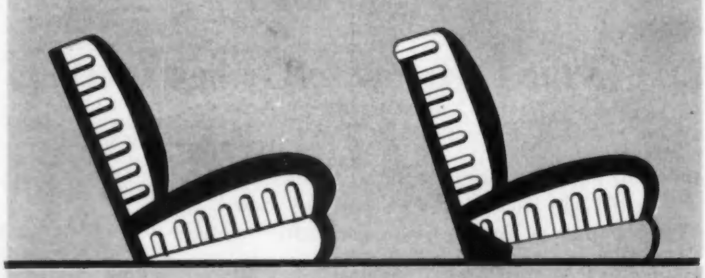

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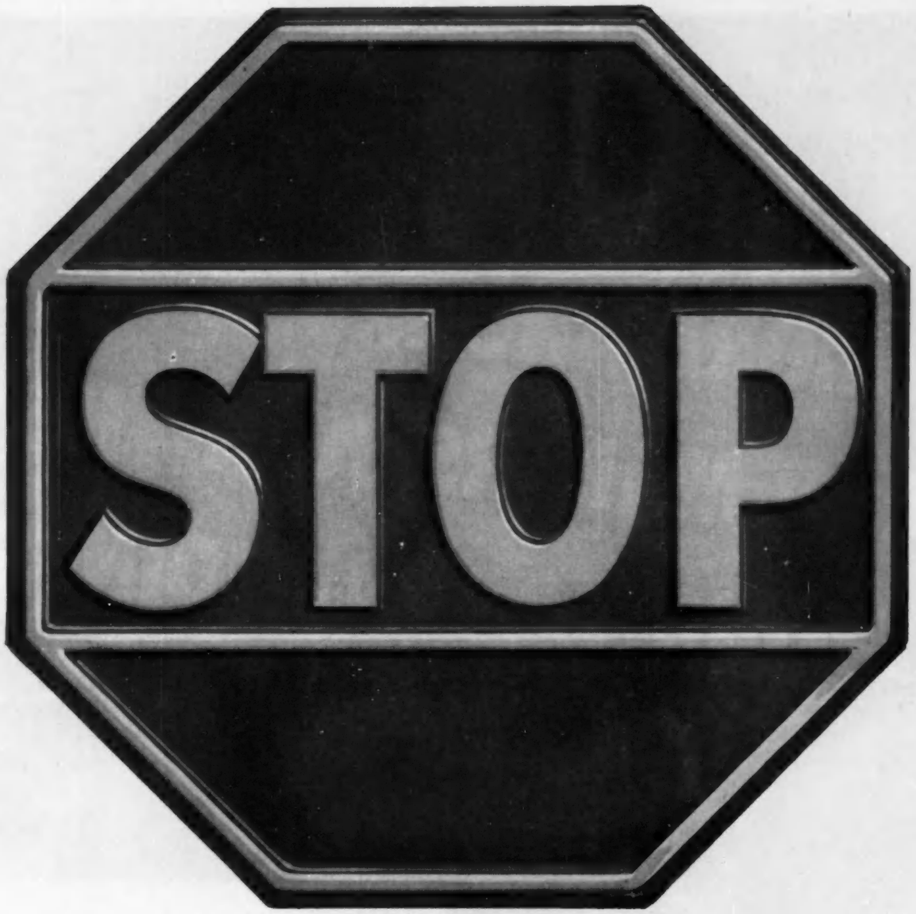

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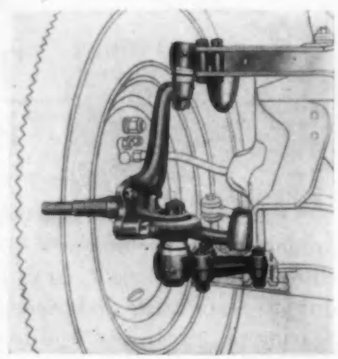

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For the Sake of Argument

Learn While You Teach . . .

By Norman G. Shidle

Industry is in the very middle of a vast exploratory expedition into the realms of applied education. Its big, practical problem, of course, is to keep production rolling at the same time both supervisors and subordinates are being "trained." Both processes have to go on simultaneously. The people involved have to be learning and doing at the same time.

This can get pretty confusing sometimes.

Experienced educators, however, are emphasizing the importance of "atmosphere" as an integrating force in the two-way educational process . . . the atmosphere in which the teaching and the learning takes place. Witness President Arthur Coons of Occidental College who says:

"Good teaching is more than simply instructors plus classes. It is achievable only in an atmosphere which is conducive to mutual confidence and interest . . . to freedom of mind and spirit, to imagination and creative thinking."

Dr. Coons was talking about good teaching in colleges and universities. But what he says is doubly applicable to on-the-job teaching or training of supervisors in industry. Good training has as its objective more than the possession of certain knowledge or the mastery of certain skills. It aims to equip its recipient to deal daily and promptly with human problems. . . . And the "atmosphere" in which those problems are met can expand them to obstacles or shrink them to routines.

The top eschelon of supervisors in any company usually are found taking major responsibility for creation of an "atmosphere" in which the best teaching and learning can flourish. But each individual supervisor, however small his area of supervision, can set the "atmosphere" in which his own "teaching and learning takes place."

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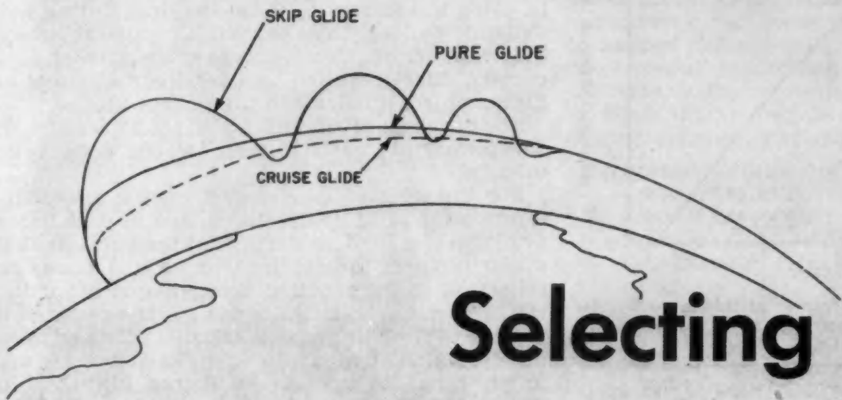
Weapon's path

(pure glide, skip glide, and cruise glide)

is one of first choices to be made in . . .



Selecting an Advanced Weapon System

George W. Jeffs, North American Aviation, Inc.

Based on paper "Selection of an Advanced Weapon System."

TO illustrate how an air weapon system is selected and developed, let us assume the requirement is for an intercontinental bombardment mission to be carried out with an expendable missile. This statement of the requirement presupposes that an evaluation has been made of the need, of the probable technical progress, and of industry's capabilities.

The first step is to select the type of missile. There are four from which to choose—the turbojet and ramjet, which are restricted to flight within the appreciable atmosphere because they depend upon air for propulsion and lift, and the glide and ballistic rockets which are inherently capable of much higher flight altitudes and speed because they derive all propulsive energy from stored propellants.

The glide missile skims at very high speed through the upper regions of the atmosphere upon which it depends for part of its lift. The ballistic missile, in contrast, is a space vehicle which meets the earth's atmosphere only during boost and re-entry periods.

Boost requirements differ markedly for these types. The turbojet may require a small rocket assist for take-off; the ramjet needs a booster for acceleration to operating speed. Rocket boosters for glide and ballistic missiles provide all the energy required for the entire flight paths.

Since the assumed weapon system requirement calls for high supersonic or hypersonic speeds, and evasive capability through in-flight course changes, the rocket-powered glide vehicle is indicated.

The next major decision concerns the nature of the flight path. The basic pure glide path is one in which the missile decelerates slowly and drops in altitude as range is traversed. Alternate paths are a cruise-glide combination and a skip-glide. All three paths are shown graphically above.

In the pure-glide trajectory, the kinetic and potential energies supplied by the booster are used to overcome drag at high speed. The initial kinetic is generally far more significant than the potential, the ratio being about 40 to 1 for this intercontinental mission. Range of the glide missile becomes very sensitive to initial flight velocity as satellitic speeds are approached. In addition, glide paths at hypersonic speeds are very sensitive to the effects of the earth's rotation, and the earth's rotational velocity vector effect on each mission flight plan must be taken into account.

In the case of a cruise-glide path, the incorporation of the cruise phase prior to glide makes possible decreasing the maximum flight velocity. Thus, earlier missile development is possible should limitations in wind tunnel facilities or technological state of the art restrict the flight velocity regime. But there is a performance penalty, since more range per unit of fuel is generally obtained from boosting to higher velocity than through cruising on the same fuel at a constant lower velocity. Also, the storage of propellants in a high speed vehicle imposes severe fuel boiling problems and consequently weapon weight penalties.

The skip-glide trajectory differs from pure glide

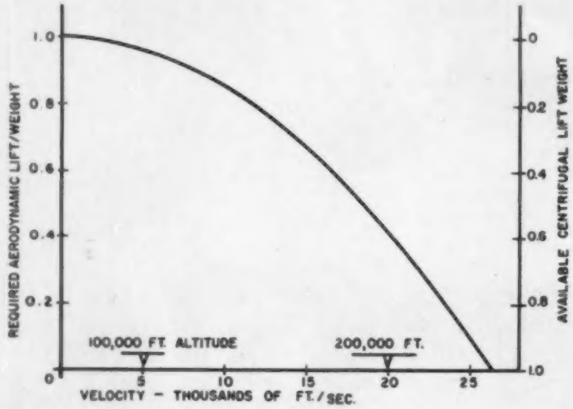


Fig. 1—Reduction of the required aerodynamic lift reduces the drag due to lift. Required lift at 20,000 fps is only 43% of the missile weight.

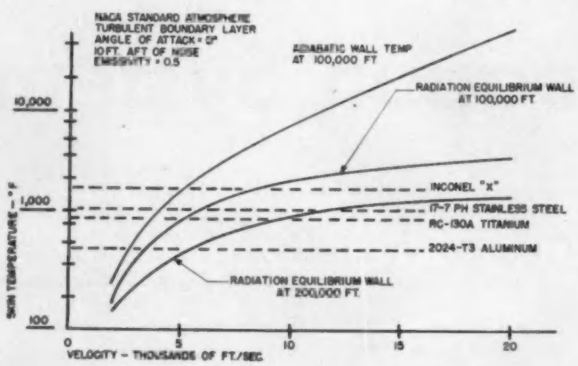


Fig. 2—Skin temperatures are lower at higher altitudes. (The curves are based upon heat input at a point 10 ft aft of the leading edge of a flat plate at 0 deg angle of attack, assuming turbulent flow and an 0.5 emissivity.)

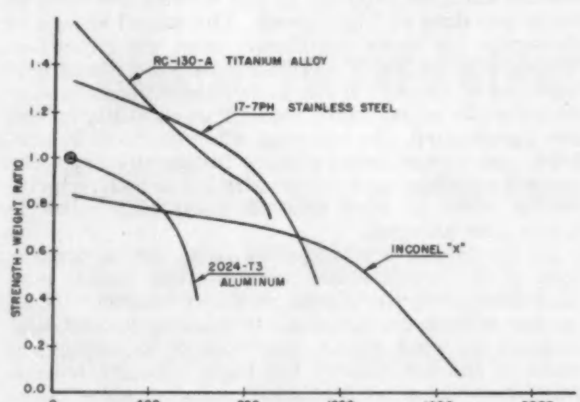


Fig. 3—Compressive strength/weight ratio versus temperature for the principal airframe materials, relative to the room temperature value for aluminum alloy. Inconel X has the best strength-weight properties for temperatures above 1000 F. It is satisfactory for temperatures up to 1500 F, but loses strength rapidly above this value.

and cruise-glide by combining an initial series of ballistic trajectories and aerodynamic pullouts with a terminal glide. Transient periods of very high aerodynamic heating and high load factors are experienced in comparison to the relatively lower equilibrium conditions encountered during pure glide. The principal advantage of a skip-glide lies in using less energy to overcome drag during aerodynamic pullouts than to glide a comparable range. The most serious disadvantage is the greater development effort required to solve thermal stress and flight control problems in the pullout phases.

For purposes of simplification, let us assume that the pure glide path is best for our hypothetical mission.

For the selected glide-rocket missile a wealth of information must be developed, and as data become available it is soon apparent that temperature is the major problem to be combated. Fig. 1 shows how reduction of the required aerodynamic lift reduces the drag due to lift. At 20,000 fps the required lift is only 43% of the missile weight. This enables a missile which glides at the angle of attack for maximum range to operate at higher altitudes, and these altitudes strongly decrease structural temperatures through the reduction of heat transfer coefficients.

The powerful effect of the missile's altitude upon the skin temperature is shown in Fig. 2. It can be seen that at an altitude of 100,000 ft a velocity of 7000 fps produces approximately the same equilibrium wall temperature as a 20,000 fps velocity at 200,000 ft.

The effects of temperature on material strength/weight ratio must be taken into account carefully in the selection of the final trajectory and the peak temperature that the structural material is permitted to reach. The compressive strength/weight ratios versus temperature for the principal airframe materials are shown in Fig. 3, relative to the room temperature value for aluminum alloy.

Very high speed flight can also produce thermal stress and warpage problems resulting from unequal heating of adjacent surfaces.

The foregoing present only a few of the structural considerations for which variables must be carried into the subsequent optimization procedures.

At this point consideration is given to some of the design variables essential in fixing the configuration of the missile itself. The procedure is to define the important variables, assign a region of values to them, then solve for the missile design which represents the best combination of these variables. On the basis of preliminary estimates, four basic body volumes are selected for inclusion in the design optimization study.

Missile lift/drag ratio, cooling requirements, and airframe weight are all strongly influenced by body fineness ratio. Hence this ratio is a prime variable in this study. If possible, the nose radius of the body designs would be studied as a special problem and the best solution applied to all designs.

A similar independent approach might be used in selecting the aerodynamic configuration of the glide vehicle, one of the most important design variables. In this case, a single representative payload, body volume, and body fineness ratio would be selected. Alternate aerodynamic arrangements represented by the conventional wing-tail, delta, and canard ar-

rangements would be evaluated and the most promising configuration selected. Such independent solutions are most important in reducing the total number of combinations in design optimization studies.

Upon definition and assignment of values to the prime variables, only a few of which have been mentioned, the actual task of solving for the best combination can be started. The first step is the definition of a criterion or parameter for evaluating the multitudinous combinations of variables. For optimizing the glide missile configuration the basic parameter selected might be the lift/drag ratio divided by glide vehicle gross weight for a given range.

Because of the large number of variables and their interrelationship, it is highly desirable to mechanize the engineering equations for solution on high speed computing machines. This insures adequate treatment in a reasonable period of time. The machine solution searches out the highest value of the optimization parameter and also, upon interrogation, solves for the corresponding values of each of the prime variables. The procedure for selecting best values is illustrated graphically in Fig. 4 for three arbitrarily chosen variables.

Selection of the booster follows, once the best type of glide rocket missile has been defined.

The curves in Fig. 5 express the relationship between characteristic velocity and mass ratio for four propellant combinations. The characteristic velocity for the glide vehicle lies in a band between the required velocities for a long range ballistic missile and for a satellite. For purpose of example, it will be concluded that the logistics of the liquid oxygen-hydrazine propellant combination are most compatible with the developmental time period for the advanced weapon system. A two-stage liquid oxygen-hydrazine booster is selected even though this involves a considerably greater booster gross weight than if a more energetic propellant combination were selected. The tandem stage arrangement represents the simplest structural design and the cleanest aerodynamically.

With propellant combination, number of boost stages, and booster configuration selected, effort is now directed toward optimization of the interrelated booster design variables. The most useful approach is one which generalizes the boost requirement with respect to glide vehicle weight and begin-glide velocity.

The main objective of booster optimization is to determine the values of the design variables which minimize the size, weight, and cost of the booster designs while satisfying the varying boost requirements. At this point the basic missile-booster design is defined in sufficient detail to provide a sound framework for added studies to "firm up" the design.

Definition of the basic missile also serves as the starting point for evolution of the other related elements of the weapon system. Each element is subjected to intensive study, and as the system design progresses into the firm-up stage, compromises are made to get the best integrated overall system. The concept of system effectiveness is simply how well does the system do its job in quantitative terms. And to apply the concept one must know what design factors have a significant influence on the job performance.

The job of a bombardment system can be conceived to be the neutralizing of surface targets with the payload of the air vehicle. To evaluate effectiveness, the job must be defined more explicitly in terms of the number of targets, their character and locations. If the targets are passive, then the simple measure of effectiveness is the total cost of neutralizing the targets against the opposition of a specified defense system. Total cost here implies development, stockpiling, and operational costs.

Obviously, the determination of the minimum cost values of the air vehicle design parameters requires explicit knowledge of the effect of:

1. Speed, altitude, and other performance items upon losses to enemy action in the air.
2. Launch base design and ground support upon losses on the ground due to enemy action.
3. Design parameters upon delivery accuracy and reliability.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

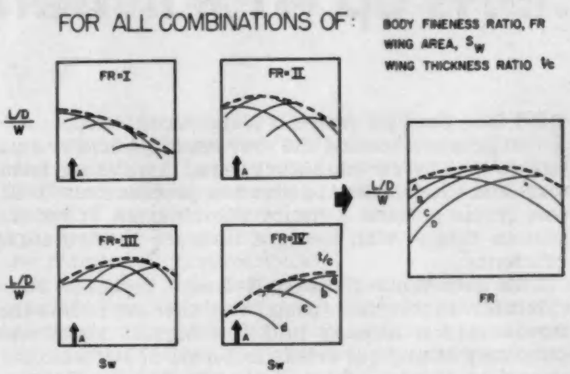
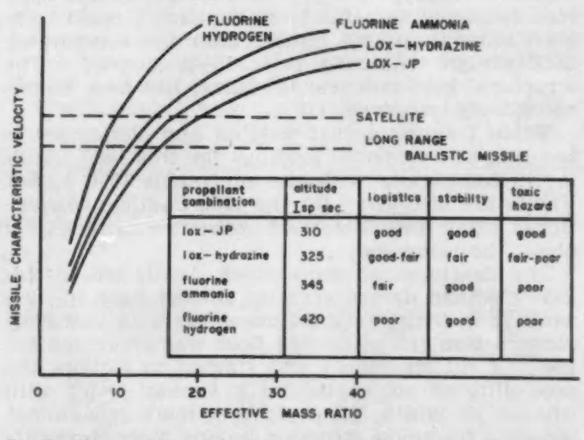


Fig. 4—Typical optimization procedure for three arbitrarily chosen variables. The best value for each variable is obtained by cross-plotting as shown in the right hand curve.



propellant combination	altitude Isp sec.	logistics	stability	toxic hazard
lox-JP	310	good	good	good
lox-hydrazine	325	good-fair	fair	fair-poor
fluorine ammonia	345	fair	good	poor
fluorine hydrogen	420	poor	good	poor

Fig. 5—Characteristics of four chemical propellant combinations ranked as to energy (in table) and relationship between characteristic velocity and mass ratio for the same four combinations.

S. L. Milliken, Cadillac Motor Car Division, GMC and J. R. Parker, A. O. Smith Corp.

Based on paper "Cadillac Frame—A New Design Concept for Lower Cars."

NEW CADILLAC FRAME...

... is up 41% in bending rigidity; 7½% in

THE 1957 Cadillac frame is a significant step in design progress toward the ever lower passenger cars still sought by car manufacturers. Stemming from tests and experimental designs in process since 1950, this frame permits a happy combination of reduction in height with a slight increase in structural efficiency.

This new tubular-center-X-frame design is considerably more rigid than was the 1956 Cadillac frame—which already had the highest structural efficiency of any car frame in terms of stiffness per pound of weight adjusted for wheelbase. For example, the bending rigidity of the frame of the 1957 model 62 4-door hardtop sedan exceeds that of the frame of the equivalent 1956 model by 41%; its torsional rigidity by 7½%. If the rigidity had been maintained at the 1956 level, the frame could have been more than 10% lighter than the comparable 1956 design. Actually it is 4½% heavier. The structural performance, of course, has been correspondingly improved.

Table 1 shows actual weights and stiffnesses in bending and torsional loadings for this 1957 Cadillac in comparison with the equivalent 1956 model. Values are also given for the 1956 Cadillac conventional sedan and other 1956 conventional sedans of about the same size.

The development work which finally led to this 1957 Cadillac design actually started back in 1948 when A. O. Smith took a Hudson car with unit body construction (in which the floor was depressed below the sill structure) and started to explore the possibility of accomplishing a similar result with what A. O. Smith felt could be a more economical, separate frame construction having more flexibility in design.

Most of the design possibilities considered in the beginning seemed to promise substantial reduction in efficiency. It appeared necessary to reduce section sizes, to create offsets in the members, with resulting secondary loadings, or to do both.

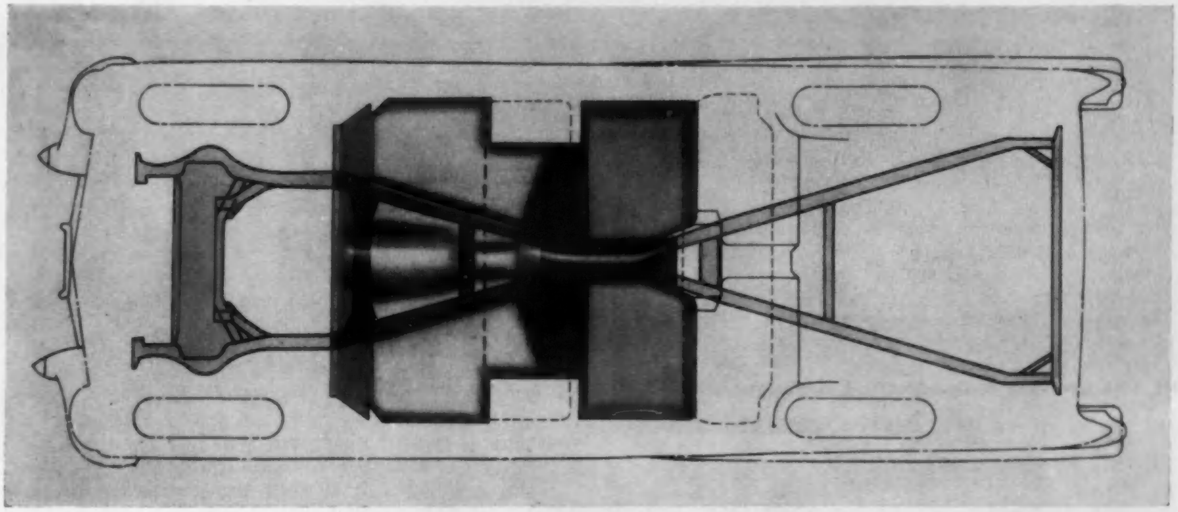
But placing the side members in a long X arrangement with the X at the front of the rear compartment floor seemed to offer better possibilities. It would differ from the conventional X-member frame in two important ways:

1. The crossing point of the X was moved rearwardly from its customary position under the front seat to a point just behind the front seat in the rear compartment floor.
2. The parallel side members used in the conventional frame were eliminated entirely. The X-member itself was designed to perform their function.

Experiments showed that the frame width and height in the area of the rear compartment floor could be made less than the width and height of the existing propeller-shaft tunnel for most of its length. Frame depth in this important midsection could be 6½ in. . . . a tremendous gain from the 4½–5 in. available at that time in more conventional frames.

Section depth dimensions in other parts of the frame could also be quite satisfactory since, in the front floor compartment, these sections were near the transmission and could take advantage of the crown in the floor necessary to provide clearance for that unit.

So far as the chassis itself was concerned, the X type of frame was by far the most attractive of the alternatives studied. Section dimensions were excellent and the main structural parts were generally in good alignment; such offsets as were required could be readily supported by cross-frame bracing. Fig. 1 shows this original design and demonstrates



torsional rigidity, yet only 4½% heavier.

the relatively good alignment and adequate section sizes. In Fig. 2 is shown the way in which the frame of this design allowed clearance for the depressed floor. In Fig. 3 are indicated typical section properties obtained with the experimental design in comparison with the properties of a conventional box section frame of the same vintage. The conventional box frame would not have accommodated the desired floor; the experimental frame did provide clearance and yet accomplished this with an improvement rather than a reduction in section properties.

So, it was apparent, the frame itself could be quite efficient. But how about the performance of the complete vehicle? . . . And would the lateral rigidity be sufficient to avoid side shake? Could the rear suspension attaching points, which had to be overhung on brackets, be made suitably rigid and durable?

The first of these questions was the most critical. So, A. O. Smith set up an experiment to evaluate it. The chassis frame for a typical 1950 car was redesigned and built in such a manner that it could be easily modified to represent several variations of this basic construction and the production body was reworked to suit. Static tests were made on the frame, the body, and the combination with each of the frame design variations.

As expected, the frame itself was very efficient, providing excellent stiffness both in torsion and in beaming. But also, the frame and body combination reflected the same stiffness improvements inherent in the frame itself.

Let us discuss for a moment the reason the engineers had hoped this type of frame might cooperate efficiently with the body structure since this test, as well as others made since, seems to justify this reasoning. While frame and body must resist both torsional and bending loads, we will talk in terms of bending resistance only since it is the easier to depict and the principles are the same.

The thought, now confirmed, that this type of

Table 1—Complete Car and Frame Comparison for a 1957 Cadillac and Several Other Cars

	Complete Car		Frame		
	Torsional Rigidity, lb-ft/deg	Max Bend Deflection, in.	Weight, lb	Torsional Rigidity, lb-ft/deg	Max Bend Deflection, in.
1957 Cadillac Sedan De Ville	5560	0.047	410	2900	0.102
1956 Cadillac Sedan De Ville	5200	0.084	393	2700	0.144
1956 Cadillac 4-Door Sedan	5500	0.062	369	2590	0.160
1956 Car A 4-Door Sedan	5300	0.050	330	1860	0.171
1956 Car B 4-Door Sedan	4160	0.047	325	1450	0.152
1956 Car C 4-Door Sedán	4750	0.031	377	1880	0.121

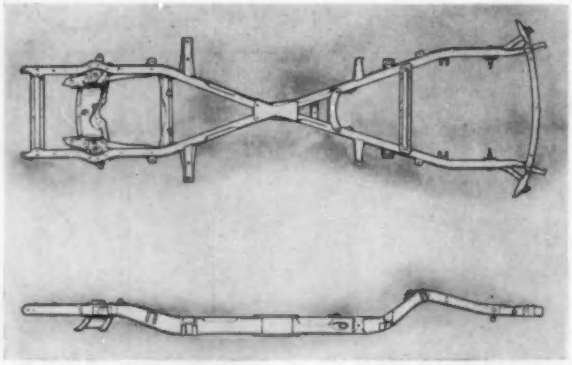


Fig. 1—X-type frame developed for 1951 experimental car.

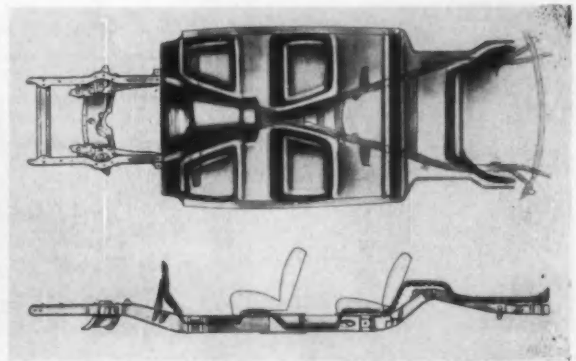
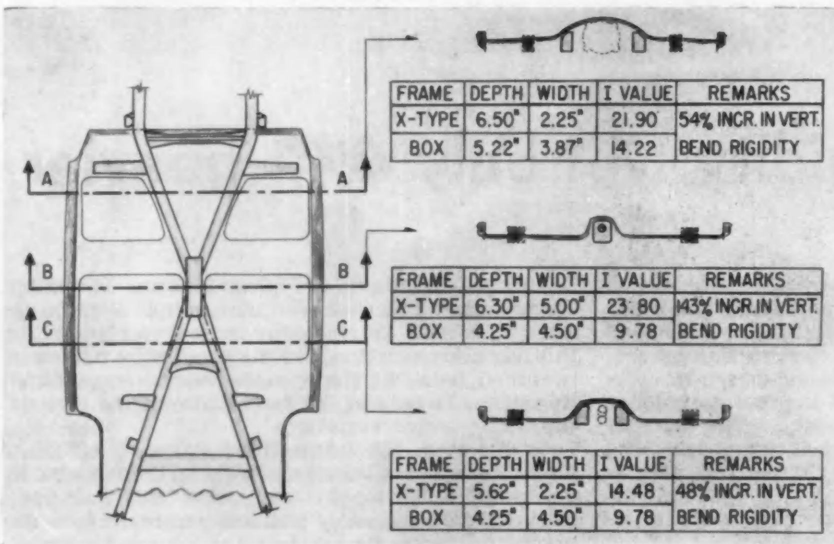


Fig. 2—X-type frame and body floor used on 1951 experimental car.



FRAME	DEPTH	WIDTH	I VALUE	REMARKS
X-TYPE	6.50"	2.25"	21.90	54% INCR. IN VERT.
BOX	5.22"	3.87"	14.22	BEND RIGIDITY

FRAME	DEPTH	WIDTH	I VALUE	REMARKS
X-TYPE	6.30"	5.00"	23.80	143% INCR. IN VERT.
BOX	4.25"	4.50"	9.78	BEND RIGIDITY

FRAME	DEPTH	WIDTH	I VALUE	REMARKS
X-TYPE	5.62"	2.25"	14.48	48% INCR. IN VERT.
BOX	4.25"	4.50"	9.78	BEND RIGIDITY

Fig. 3—Comparison of section properties—1951 X-type frame versus conventional box frame.

frame might cooperate efficiently with the body structure, stemmed from an analysis indicating that a car's various structural parts can be resolved into two key points:

1. That the understructure functions as the principal load-carrying member, which is reinforced by the superstructure to whatever extent the capability of the superstructure will permit (Fig. 4).
2. That the full reinforcing effect of the body superstructure can be achieved so long as firm attachments are made at a few key locations. To transmit the resisting moment offered by the body roof through the side walls and inboard to the location of the tubular-center-X type of frame, it is necessary to have rigid cross-structure at only four points. Such cross-structure already exists or can be provided readily, as shown in Fig. 5. The body dash serves as an admirable cross-member to translate loads from the frame location to the front of the cowl.

At the front door pillar a downward load on the body is attained by a substantial outrigger bracket under the toe board with double mounting to the body. At the rear door latch pillar, another location at which the frame must load the body downwardly, a body cross-member can be provided under the rear seat, or the structure of the back of the seat can be effectively utilized. At the rear end, frame and body structure can be brought together for suitably rigid attachments.

In addition to these four main connections, additional attachments between chassis frame and underbody can be made as and if required to reinforce the floor for local loadings or to carry loads imposed by stub pillars on hardtop models.

The front fender structure can be so attached as to transmit a greater or lesser amount of load from the front section of the frame into the body cowl, depending on the degree of stiffness desired and the amount of engine noise pickup and front end harshness considered tolerable.

Subsequent tests confirm that frame-to-body attachment efficiency with this style of frame can be

equal to previous conventional practice. A given body structure *does* reinforce the frame against overall bending and torsional loads to about the same degree as the same body reinforces typical frames used in the past.

Data from this original experimental car and from another more refined buildup, completed in 1954, proved useful to Cadillac in their design of the 1957 models.

Fig. 6 shows a photograph of the underside of this second experimental car showing the relationship of the floor and the frame. The underbody of this car was rebuilt to be structurally equivalent to conventional practice of that period having rocker sills and body cross-members of conventional dimensions. The narrowest part of the frame is positioned just behind the front seat pan and there is no straight tubular section such as is used on the 1957 Cadillac resulting in a diverging tunnel in the rear passenger compartment.

Later study proved that it was an unnecessary compromise.

The complete car was 42% more rigid in torsion than the production car from which it was rebuilt having a static deflection rate of 7040 ft-lb per deg of twist over the wheelbase. It was 270% more rigid in bending than the production car. Weight had been increased by 18 lb. It should be noted that these great stiffness increases were not necessarily desired. The aim had been to build a car of about the same weight, so that stiffness changes would represent design efficiency.

One of the first and most important matters to be considered in the application of this basic design to Cadillac's production was the matter of varying wheelbases.

Cadillac's normal complement of models involves wheelbases of 129½, 133, 150, and 156 in. Since some of these models were produced in limited numbers, it would have been impractical to provide special tooling for each wheelbase, as would have been required if the original concept of the frame of X formation were used. If, on the other hand, the midsections could be lengthened to provide for the increased wheelbase, the same basic tooling would suffice for all models.

A test program was inaugurated to explore the loss in efficiency which might result from departing from a common intersection point of the four X-member legs. The principle was well established that extending the central tunnel section would not greatly harm stiffness and that the changes which did result could easily be compensated by modest changes in gage in the principal parts. The tools for the higher volume models could be inserted to allow for the gage changes without any substantial cost penalty. The final design of the 1957 model 75 frame for the 150-in. wheelbase 8-passenger car is lighter and considerably more rigid than its 1956 counterpart. Since it was not necessary to widen the rear of the propeller-shaft tunnel to allow the rear legs to diverge from a point at the center of the frame, the minimum-sized tunnel desired by Cadillac could be achieved without penalty.

Two other design features were discovered during the development tests made for Cadillac:

1. The contour of the tubular center section, particularly in the region in which it branches out to merge with the extending legs, was found to be a very important factor in the rigidity of the entire frame. In one of the tests, an increase in torsional stiffness of the complete frame of more than 20% was achieved through a change in contour of the top tunnel member without any increase in section size, material thickness, or weight.
2. Bulkheads or shear plates at the ends of the tunnel section were found to be very desirable in terms of the increase in torsional efficiency they produce. In the 1957 Cadillac frame, a bulkhead was applied at the front end of the tunnel and a short cross-member just rearward of the tunnel to achieve the same effect.

Both the external contour and the bulkhead are

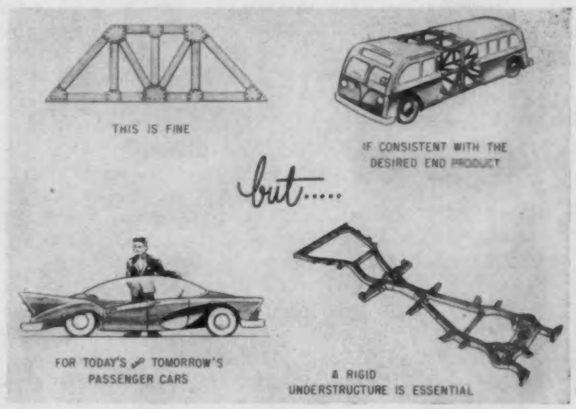


Fig. 4—Understructure functions as principal load-carrying member, which is reinforced by superstructure to whatever extent the capability of superstructure will permit.

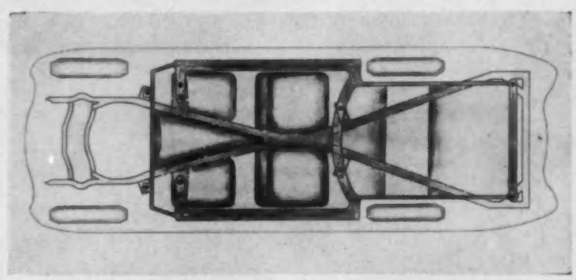


Fig. 5—Effective cross-structure in body-to-frame tie-up.

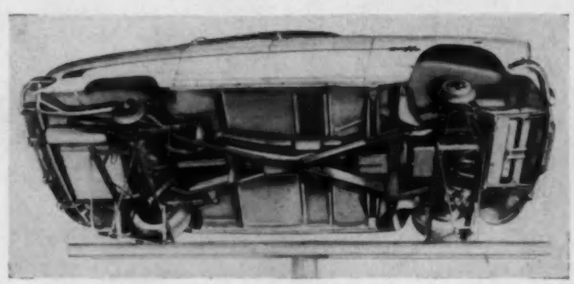


Fig. 6—Bottom view of 1951 experimental car.

effective because of the action of this portion of the frame in resisting overall torsional loads. When torsional loading is applied to the frame, one front beam and the diagonal rear beam are loaded downwardly while the opposite members are loaded upwardly. This results in a combination of cantilever bending and torsion in the legs themselves and a condition of almost true torsion at the center of the tubular section. The stresses in the extending beams must be transmitted into the tubular center section with a minimum of buckling or other secondary distortions in order to provide optimum rigidity.

Cost comparisons between different designs are somewhat difficult to make. But detailed evaluations of a number of comparable frames prove this basic design to be little, if any, more expensive, for a given end result, than conventional frames of the recent past.

Cadillac's New Tubular-Center-X Frame

COORDINATED design of frame and body was essential to produce the necessary strength for the new Cadillacs which were to incorporate a new tubular-center-X-frame design.

Head room was not to be reduced in either the front or rear seats so seat chair height and cushion thickness could be maintained only if a more efficient floor-pan cross-section could be developed.

The cross-section through the rear floor plan shows (Fig. 1) the side bar and X member of the 1956 frame in relation to the proposed floor pan for the Eldorado Brougham. The floor pan for the 1957 conventional 4-door sedan is 2 in. higher than this, but the impossibility of using the former type of frame in either model is apparent. So the development of the new frame started with these requirements.

The general dimensions of the frame were dictated by the fixed location of the usual chassis and body components. Between these generally fixed points was to be a frame of maximum efficiency.

Fig. 2 shows the frame design that satisfied these requirements so thoroughly and made possible the new and radically lower bodies without encroaching on the passenger's room.

The basic shape of the frame was attractive in that the disposition of the main structural members did allow the lower bodies and lower floor pans required by Cadillac's new styling. Moreover, the basic design could be modified to the needs of the different bodies and wheelbases. In addition, the new frame offered more beam stiffness and torsional rigidity without a penalty in weight, even in the longer wheelbases.

Much experimental design and testing were involved in the location and the length of the tubular section at the center of the frame. Earlier designs had the junction under the front seat and with the front and rear extending beams in line. This followed the practice of former frames in utilizing the height available under the front seat. But the spread of the rear extended beams brought the frame into the floor-pan well, as occurred on the former type of frame shown in Fig. 1.

Further study and experimental testing showed that the junction could be moved rearward and lengthened into a tubular section (as shown in the picture of the 1957 frame in the body outline of the model 62 sedan at the top of page 21). This allows a narrow tunnel in the rear floor pan, even in the 8-passenger models, where the rear seat is 28½ in. farther from the front-seat back than in a coupé. This flexibility in design, with no impairment of strength, is one of the marked advantages of the tubular-center-X frame.

With the new frame the tunnel over the propeller shaft is only 0.4 in. higher (in relation to the propeller shaft) than for the former X type

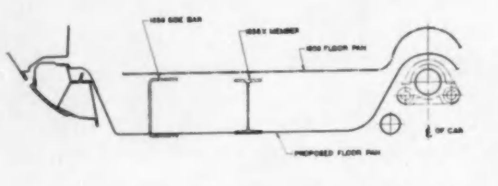


Fig. 1—Section through Eldorado Brougham rear floor.

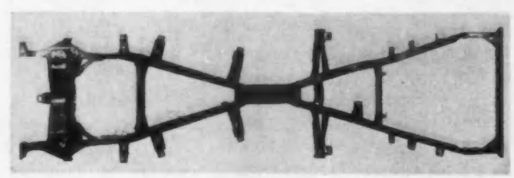


Fig. 2—Frame design that made possible new and radically lower bodies without encroaching on passenger's room.

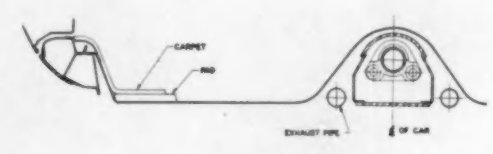


Fig. 3—Rear floor pan for Eldorado Brougham.

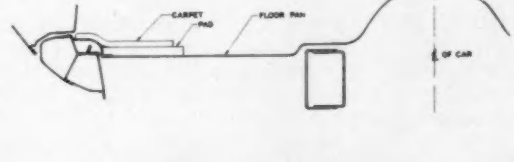


Fig. 4—Section through front floor of Eldorado Brougham.

Further, it appears to be less costly than any of the alternative designs proposed to date for very low floors.

The increased structural efficiency generally allows a weight reduction, if no increase in stiffness is desired.

Other design possibilities for low cars exist, both in production and in the development organizations of the industry. As development progresses, or as the functional and spatial requirements of passenger cars change, the relative merits of these designs will change. From today's perspective, however, the tubular-center-X type of frame has much to recommend it as a solution to tomorrow's structural design problems.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members, 60¢ to nonmembers.)

of frame and is 3 in. wider at the base. This is for the 4-door sedan body. The additional tunnel width is on the centerline of the car and between the feet of the rear-seat middle passenger, where it does not bother him. This floor pan allows a better rear-seat chair height than there was in the 1956 4-door sedan, without impairment of headroom. The 1956 entrance heights, from seat cushion to door-opening windcord and from floor pan to windcord, were also maintained in the 1957 4-door sedan. This is in spite of the 3-in. reduction in overall height.

On the Eldorado Brougham, with its lower floor pan, the tunnel must clear the exhaust pipe also (Fig. 3) so it is wider. However, as the rear seat of this car is designed for two passengers, and has a center arm rest over the propeller-shaft tunnel, the greater width does not bother them.

Because there is no side bar to clear at the body rocker sill, the ledge is only 6 in. wide and is stepped over easily in entering or leaving the car.

The ledge at the rocker sill is narrow at the front doors also, and this improves the ease of entrance. Fig. 4 shows the floor cross-section at the 20-in. line (the passenger's feet) in the front compartment. This section is for the Eldorado Brougham, but it is typical of all the bodies.

The frame-member shape was modified in this front floor area by making it wider and shallower than the normal proportions. Tests showed that this did not impair the strength of the frame, and it does allow a lower plateau for the accelerator mounting.

With all the frame structure at the centerline of the car, there is more height and width available out at the body rocker panel for the attachment of floor-pan cross-bars. Fig. 5 shows a cross-section of the floor pan in the center-pillar area, just forward of the depressed well in the rear compartment floor. Note that the floor-pan cross-bar is deeper and has a better attachment to the rocker sill than was possible with the former frame. The anchorage for the stub pillar on 4-door hard-top models is also stronger and is reduced in size.

The tubular section of the frame provides a solid, and protected, mounting for the propeller-shaft intermediate support. (See Fig. 6.) This is simple, light, and inexpensive, compared to the cross-member that has been required with a ladder-type frame. The rubber-insulated mounting is shown, and also the weld joint between the front and rear extending beams on all frames but the Eldorado Brougham. The beams for that frame are one-piece, as they are not interchangeable with the other frames.

The bulkhead at the front of the tubular section is an important member in the strength of the junction. Another transverse member is just behind the tubular section, and between the rearward extending beams. It is in line with the No. 4 body brackets, and is arched to clear the propeller shaft at bump position.

This type of frame is adaptable to Cadillac's full range in wheelbases by merely lengthening the tubular center, so there is good interchangeability of frame tools and parts through the established series of cars.

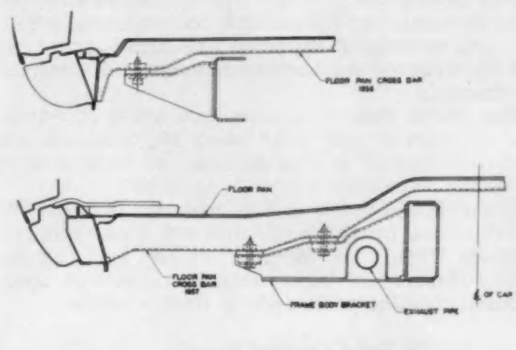
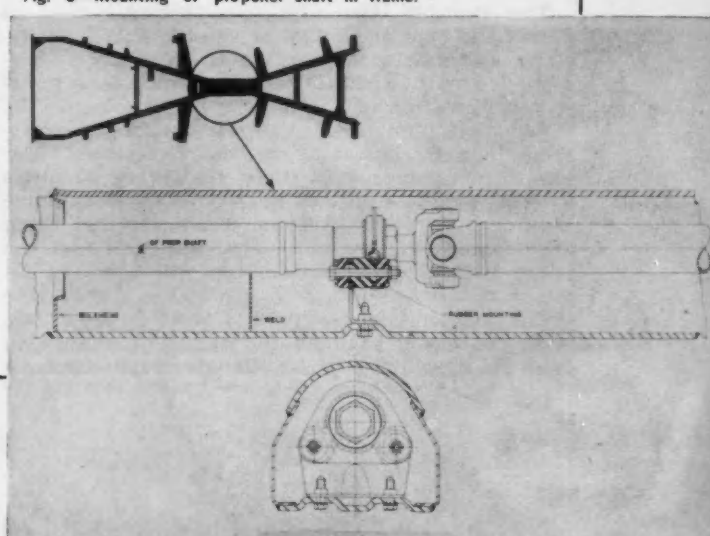


Fig. 5—Section through floor at center pillar, for Eldorado Brougham.

Fig. 6—Mounting of propeller shaft in frame.



Hybridizing produces . . .

SCAN Airborne Navigation

. . . from self-contained and externally

David J. Green, Learcal Division, Lear, Inc.

Based on paper "Theoretical Concepts of New Airborne Navigation Systems."

A self-correcting automatic navigator (SCAN) which links self-contained dead-reckoning instrumentation with a ground-referenced position indicating system of the radio type has been developed by Lear.

SCAN represents a fundamental departure from current techniques, yet the instrumentation is obtained by relatively simple and conventional methods. The principles involved are taken primarily from the fields of statistical processes and information theory.

Since SCAN uses data from two types of equipment in such a way that each supplements the other to overcome the weaknesses of both, a brief look at the source equipment is in order.

All navigation systems fall into two classes: the self-contained in which the primary measurements are made within the moving vehicle, and the externally referenced, which rely on radiations from, or communication with, remote data sources.

Self-Contained Systems

The self-contained include inertial and doppler types as well as dead-reckoners. Their fundamental property is a time-dependent accuracy.

The inertial type uses two accelerometers to detect the rate of change of velocity along north-south and east-west coordinates. The accelerometers are maintained in this orientation by a gryoscopically stabilized platform.

For short flight intervals very satisfactory accuracies can be had with inertial navigators. For long interval problems, there are severe penalties in cost, weight, and complexity for the attainable accuracy. Virtually everyone will agree that when development makes such penalties small and the system accuracy high, this system will represent the ideal.

The doppler-type navigator is based on the classic principle which predicts the apparent change in observed frequency of wavelength when there is relative velocity between the source and the detector of a propagated wave. In the navigation application, the radiation is a microwave signal emitted from the moving aircraft; this signal is reflected from the earth's surface and detected aboard the aircraft.

The doppler method is only a velocity measuring technique, and since its coordinates are attached to the airframe it must be associated with a good compass and dead-reckoning computer. The latter items often impose the primary performance restrictions, but cost, weight, complexity, and power requirements are all deterrents.

The classic dead-reckoning system operates from heading, airspeed, and wind input data. It requires little comment, but is shown here in block-diagram form (Fig. 1) because of its relevancy to SCAN.

The input data is heading (θ) and TAS ($\dot{S}$), and such modifications to these data ($\Delta\theta$ and $\Delta\dot{S}$) as are known. The modified data (θ_c and $\dot{S}_c$) are then transformed from their polar coordinate form into $\dot{S}_{ns}$ and $\dot{S}_{ew}$, these being the aircraft velocity components along arbitrarily chosen north-south and east-west ordinates. The time integration of these velocity components results in logging the distance traveled as expressed in the cartesian form (ΔS_{ns} and ΔS_{ew}). The addition of the initial position of the aircraft at the outset of the mission gives present cartesian position (S_{ns} and S_{ew}); conversion to the polar form gives data in the more commonly used bearing and distance from the coordinate center (θ_t and S_t). If the negative value of the target or destination is entered in place of the initial position, θ_t and S_t will report continuously the bearing and distance remaining to the target.

Externally Referenced Systems

The externally referenced systems as a class include all of the radio, radar, and optical methods. Only the radio systems need to be reviewed here.

System

referenced systems.

These include VOR-DME, TACAN, VORTAC, Loran, Decca, Sonne, Navarho, Gee, and many others.

The radio-type ground-referenced systems are generally limited by propagation effects, mapping inconsistencies, and countermeasure vulnerability.

The deficiencies of the self-contained and radio systems are substantially different in character. With the former it is the loss of accuracy with time; with the latter it is the line-of-sight or other terrain-dependent limitations and susceptibility to jamming. It is this difference which gave rise to the possibility of the hybrid, SCAN.

SCAN System

The SCAN system will operate in a manner illustrated in Fig. 2. Here the data from the two navigational systems are shown to be compared and any difference in the two sets of data is then applied to an "optimum" filter. The output of this filter then supplies correction data so as to cause the self-contained system (the dead-reckoning computer) to come into long-term agreement with such samples of data as are supplied by the external system.

This filtering of data is of vast importance. Even in the absence of deliberate interference, radio data in mountainous terrain or below the line-of-sight will contain some amount of valid data (by anomalous propagation: back scattering, reflection, and so forth) hidden in an undetermined amount of false, or noisy, data. Sophisticated filtering techniques can abstract this valid data without being penalized by also accepting evident faulty data.

The technique for examination of radio data prior to acceptance is based upon the predictable accuracy of the airborne system. Missions will generally originate in areas where radio navigational aids are available. The initial portion of any flight will, therefore, be characterized by essentially continuous radio data. In the system to be described such continuous data will calibrate, or correct, the meas-

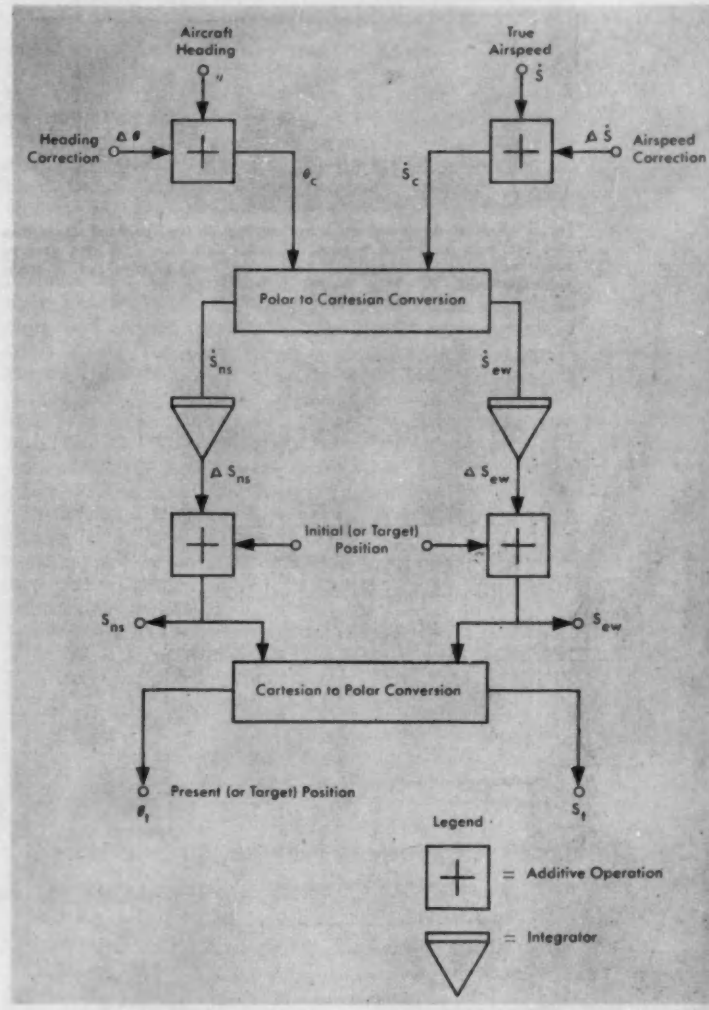


Fig. 1—Block diagram of simple dead-reckoner (open loop)—one of navigational systems used in SCAN, the self-correcting automatic navigator.

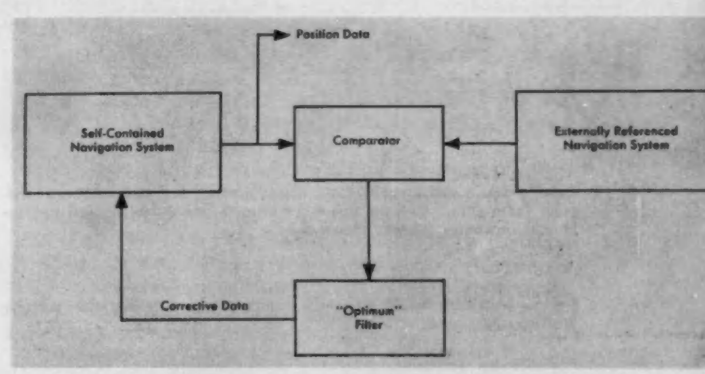


Fig. 2—Simplified diagram of SCAN method. Data from two navigational systems are compared and difference is applied to "optimum" filter. Filter supplies correction data to bring self-contained system into agreement with data supplied by external system.

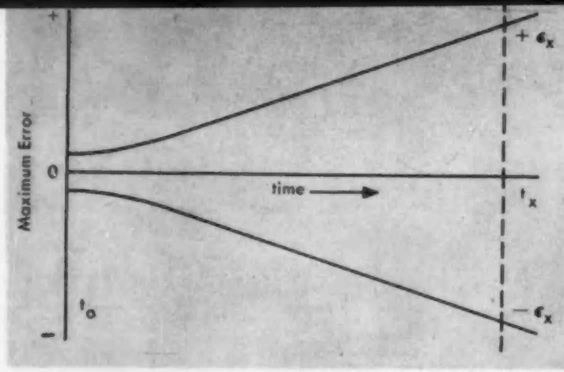


Fig. 3—Typical maximum error as function of time without correction data for dead-reckoning system. If radio data comes in at a rate to keep the system corrected, the acceptance range of data can be made relatively small.

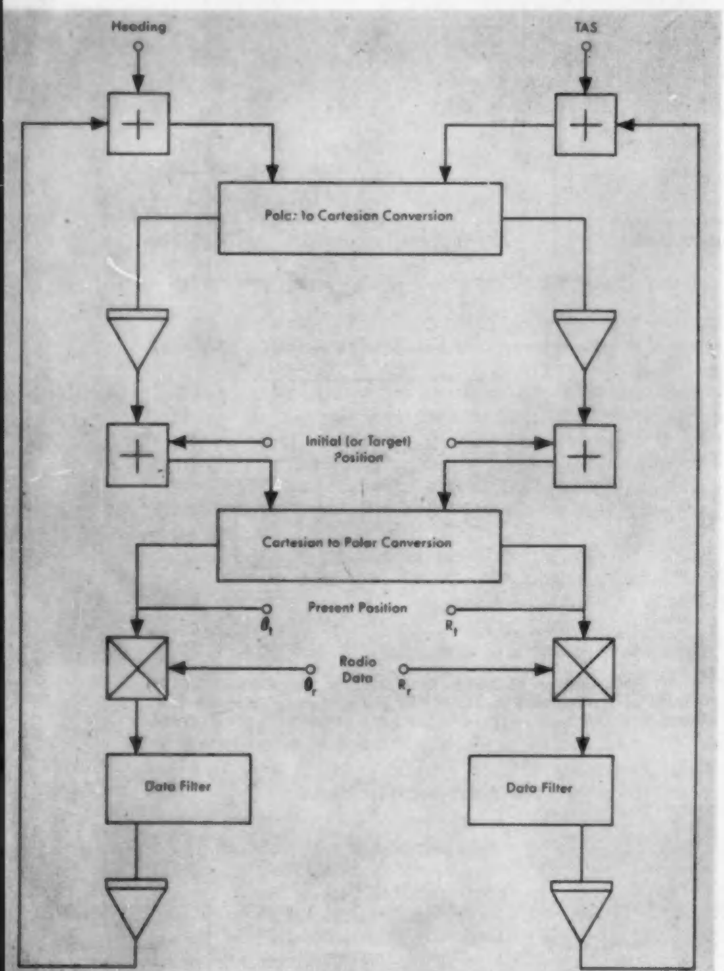
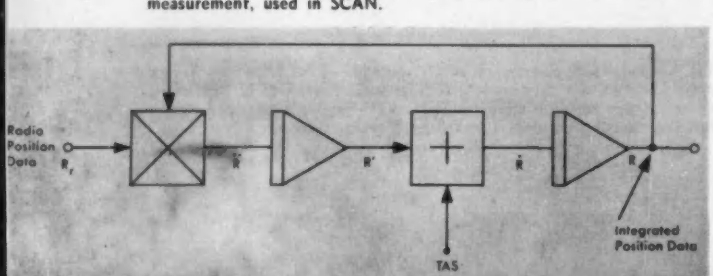


Fig. 4—Block diagram of SCAN using heading and true airspeed with polar radio data. Diagram above position θ_t and R_t duplicates diagram of self-reckoning system shown as Fig. 1.

Fig. 5—Modified double integrator tracking loop with separate velocity measurement, used in SCAN.



urements used for dead-reckoning.

In any system of the general dead-reckoner type, the sources of error are known. Thus, for a specific instrumentation, maximum drift rates can be established. If correlation data ($\Delta\theta$ and $\Delta\dot{S}$) has been supplied to the equipment over a period of time, the dead-reckoning will be caused to read correctly within the limits established by such correction data. If further corrections are suddenly denied the equipment at time t_o, the maximum possible error will increase at a known rate as time progresses. A typical variation of error with time for a simple system is shown in Fig. 3.

To determine the probable validity of any sample of radio data it is only necessary to know the state of the dead-reckoning system. If radio data have been coming in at an acceptable rate to keep the system corrected, the acceptance range of data can be made relatively small; this is indicated by the small possible positional error shown at t_o in Fig. 3. If there has been an interruption of time (t_x), then the possible dead-reckoning error might be as large as plus or minus ϵ_x and the acceptance range of radio position data must be correspondingly increased. Since the present indicated position plus or minus ϵ_x represents the confidence limits that one can apply to the airborne data, then all radio data indicating position errors in excess of this amount can be given a credibility coefficient of zero, or be disregarded. However, consideration must be given to the weighting or credibility coefficient for data within the confidence limits.

Since the short-term error generating mechanisms within the self-contained system are largely of a random nature (for example, uncompensated gyro drift and noise effects), statistical processes can be applied effectively. It can be shown from probability theory that error values between the confidence limits will have likelihoods which follow the normal density function or Gaussian law.

Implementation of the SCAN method can be accomplished in the manner block-diagrammed in Fig. 4. From the points where the locally measured heading and TAS are entered to the terminals where present position (θ_t and R_t) are available, this diagram duplicates Fig. 1. If, at this point, the radio derived position data (θ_r and R_r) are subtracted from the dead-reckoning present position, the indicated error in angle and range is determined. The indicated error in each ordinate is then processed in a data filter to establish its credibility coefficient. The weighted error in each channel is then integrated to establish the correction to be applied to the corresponding dead-reckoner input. A rate network may be required preceding the integrator in order to provide stability in each of the overall loops since they contain two cascaded integrators.

The use of double integrator loops for dead-reckoning results in compound filtering of noise or random inputs and provides velocity memory for correctly computing through intervals without radio correction data. In Fig. 5 the double integrating loop is modified to provide for the separate measurement of velocity (TAS). If the TAS were equal to the value of R necessary to permit accurate position prediction, the value of R and R' would be zero. However, since the radio data will vary with ground speed, R' will assume a value which is the difference between TAS and ground speed, or R' will be equal

to the wind magnitude. If there are errors in the calibration of the TAS transducer, the value of R' will also reflect this. The correction in the heading channel will, in an identical manner, account for the differences between indicated heading and ground track. The two corrections that are added to the local measurements in the aircraft can, therefore, be seen to represent wind effects as well as other error generating deficiencies.

In Fig. 4 the equivalence of the overall SCAN computing loop to the double integrator loop shown in the last figure can be observed by eliminating the two coordinate converters (which offset each other). The loop starts where the radio and dead-reckoner data are compared. The two vertically disposed loops are identical except that one works in range units and the other in angular units.

The data filter shown in this figure is a device which "knows" the present state of the problem, and therefore the confidence limits, and is capable of applying a Gaussian weighting coefficient to each sample of radio data.

While the instrumentation of the example SCAN system is novel in its configuration, the functional operations, except for the data filter, are quite conventional. Integrators, coordinate converters, additive and subtractive devices are standard in the computer art. The data filter is a new system element designed with relatively low complexity.

The overall operation of the SCAN system constitutes the multiplication of the radio signal with its error distribution by the error probability distribution (weighting) of the dead-reckoner. This product is then integrated, so that the whole process is one termed "cross-correlation" in information theory. The cross-correlation technique has demonstrated ability in improving the signal-to-noise, or uncertainty, in statistical processes involving stationary time series.

Operationally, the system will continuously calibrate itself whenever radio data are available. Upon interruption of the radio data, the dead-reckoner extrapolates with the last acquired wind information and adjusts its confidence limits appropriately with time. The radio channel is continuously monitored, however, and any data falling within the confidence limits is weighted and assimilated. In this manner even sporadically available radio signals; for example, beyond the line of sight, are observed and accepted by the system. Appreciable extension of the operating range of radio navaids can be thus achieved. Although the illustrative example utilized a dead-reckoner and a rho-θ radio system, the basic SCAN philosophy is applicable to any combination of self-contained and externally referenced systems.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

10 Ways to Improve . . .

. . . crash-protection characteristics of ground vehicles are suggested. Human tolerances to forces resulting from crashes used as basis for recommendations.

Excerpts from paper by **Lt. Col. John P. Stapp and 1st Lt. Sidney T. Lewis,** U. S. Air Force

STUDY of the tolerances of human occupants of ground vehicles to the forces resulting from vehicle crashes indicate that crash protection characteristics need further improvement.

The parameters of human tolerance to experimental application of crash mechanical force have been determined with respect to rate of onset, magnitude, duration and direction. These limitations suggest the desirability of providing the following crash protection factors in ground vehicles:

1. Ground vehicles should be equipped with safety door latches to prevent ejection of occupants in accident situations.
2. Interiors of vehicles should be delethalized to increase their crash-protective characteristics. Specific attention should go to any object which could cause injury if impacted by the occupant.
3. Open-top vehicles should have retrofitted roll-over structures to protect occupants in roll-over type of accidents.
4. Bumpers should adequately attenuate the crash forces so that the force transmitted to the occupant compartment will be within the human tolerance limits.
5. Dials and hand controls should be arranged for maximum efficiency of operation. The operator should not have to divert his attention from control of the vehicle to check his instruments.
6. Tracks and locks on movable seats should be stressed for a minimum force of 5,000 lb. (This will reduce the possibility of seats tearing loose from their anchorage points and adding to the impact weight of the occupant.)
7. Steering wheels should be collapsible or present broad flat surfaces parallel to the thorax. Then, upon impact, the force will be distributed over a larger area rather than concentrated in one location.
8. All structures that can be impacted when an individual is secured by lap belt should be covered with energy-absorbing foam plastic.
9. Headrest structures should be incorporated on seat backs so as to reduce the possibility of whip lash injury to the neck.
10. Lap belts should be incorporated to prevent occupants from being ejected from the vehicle or thrown violently against objects within the automobile. (Under impact conditions, ejection from the vehicle doubles the risk of injury.)

(This abridgment is based on paper "Human Factors in Crash Protection of Automobiles." For complete paper in multilith form, write SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

More Performance Promised for Passenger Cars

Victor G. Raviolo
Director of Advanced Products Study, Ford Motor Co.

Based on talk presented before Metropolitan Section reported by Leslie Peat, field editor.

HORSEPOWER of passenger car engines will continue to increase, *provided* prosperity continues and gasoline is plentiful. We can expect at least 25% and possibly as much as 40% increase in power over the next four or five years. The power will come from pistons—not turbines.

Should, however, either the national economy or the international situation call for austerity, engine builders can reverse the power trend and increase car mileage per gallon of fuel. This would be achieved by using smaller, faster engines in smaller, slower cars.

If the trend toward more horsepower continues, increases over the next few years will come largely from increased displacement, partly from higher compression ratio, and only slightly from higher engine speeds. The increase in power will be used to drive accessories, make up for minor losses in the transmission, provide for acceleration without excessive shifting, and improve passing ability in the 50–60 mph range. Higher maximum speeds will be an incidental result of increased horsepower, but they are not an objective in themselves.

The purpose of increasing displacement is, of course, to put more air through the engine. This could be accomplished by supercharging. But it's not likely to be, over the next few years, because in current engine size ranges, it's cheaper to add cubic inches. Increasing the displacement of our eight-cylinder engine from 239 to 312 cu in. boosted its cost less than 15% of the production cost of a supercharger.

Supercharging might become relatively more attractive if engine displacement gets into the 550 cu in. range. Increasing displacement beyond that figure would require enlarging brakes, tires, and other car components—a consideration which might overbalance the first cost of the supercharger.

Compression ratios of cars in the Ford class are likely to climb above 10 to 1 by 1960 or 1961, granted suitable fuel. But the rise won't continue indefinitely. Thermal efficiency peaks somewhere around 12 or 13 to 1 compression ratio. Power does continue to increase with compression ratio, but stresses also increase considerably.

At compression ratios of 10 to 1, engines will need fuels of about 100 octane rating (Research method). Fuel injection may lessen the octane need and improve fuel economy.

Maximum engine speed will rise somewhat with maximum horsepower. But the cruising rpm will remain about where it is now, around 2400 rpm. Engine designers are reluctant to raise engine cruising speed because with higher engine rpm's engine noises take on a higher pitch—and drivers tend to relate high pitch with engine strain.

Since engine cruising rpm will be a smaller fraction of maximum rpm, the engine will operate at a lower load factor. Instead of cruising at, say, 25% of maximum power, it may cruise at 15%. City driving will be done at merely off-idle conditions. Even today the engine runs on its idle fuel system most of the time. This type of operation puts severe demands on the lubricant.

Low load factors may, therefore, lead us to a third set of nozzles in the carburetor. (And any further complication of the carburetor narrows the cost differential between carburetion and fuel injection, making injection more attractive.)

There's no reason to expect that engine coolant will run hotter in future cars than in current ones. Tests have shown that higher temperatures do not improve engine efficiency. Friction horsepower stays about the same and gross horsepower goes down.

Future Plans for Premium Fuel

Preignition is a potential problem. In fact, it's already a problem to engine designers trying to develop tomorrow's engines on today's fuels. Preignition—even inaudible preignition—can burn through a piston in 15 minutes. It can heat intake valves to 1450–1500 F in even less time. Gaskets burn out in 4 or 5 minutes.

We need a measure of fuel preignition-resistance and a measure of the engine's ability to tolerate fuel in regard to preignition. Even more important, we need fuels that won't support preignition.

In designing future engines, Ford won't hesitate to count on operating them on contemporary premium fuels. That's because the customer in anticipated future boom days isn't expected to care about the cost difference when it is only a few pennies per gallon. But Ford won't aim at super premium fuels. And as long as Ford builds six-cylinder engines, they'll probably be intended for operation on regular fuel.

Practical Turbines Are Far Off

Now that we know more about conventional gas turbine powerplants than we did a few years ago, they don't look as attractive in comparison with piston engines for passenger cars. The conventional combustion-type of turbine requires regeneration to bring fuel consumption down within reasonable limits. With regeneration, this type has no advantage in weight or fuel economy over present day piston engines and its throttle response is poorer.

It will take several more years to evaluate the free-piston gasifier type of turbine fully. It looks now as if it might be a contender with the piston engine in the future. Its throttle response, fuel economy, and first cost look good. Its torque curve is superior. But until it can develop much higher cyclic speeds than it does now, it will suffer a serious weight disadvantage.

The free-piston turbine's suitability to split installation—that is, gasifier under the hood and turbine in the rear—makes it possible to distribute engine weight advantageously in the vehicle. But fitting the two units and the connection between them into a passenger car won't be easy. The duct to the turbine must be about 3½ in. in diameter, and since it carries gases at about 1200 F, it has to have insulation and airspace around it. So there's still a tunnel, even though there's no driveshaft.

From these considerations, it appears certain that the turbine is not just around the corner and that even by 1965 there will be no great volume of gas turbine cars in production.

The day of the turbine may come eventually, of course. The problems that hinder it now may melt under the vigorous development programs under way at all the major car companies. These companies have spent $25–30 million (estimated) to date on turbine research, and they are likely to continue the work, so as not to be caught off guard in case the competition swings to turbines or some sudden development makes them more feasible.

It's not beyond the realm of possibility that some company will bring out a low-volume specialty car in a turbine version within the next few years. The turbine car, as we see it, would cost $1000–1500 more than a conventionally powered car of a slightly poorer high-end performance and slightly better low-end performance. But there's a saying in Detroit that you can sell 4000 a year of anything on wheels.

Raviolo Comments . . .

Next great changes in passenger cars will come in suspensions. Result will be better stability, ride, and handling characteristics. Look for air suspensions to spread from trucks and buses to passenger cars.

We don't really build standard cars, as many people believe we do. We build standard parts from which a great variety of cars can be assembled. Chances are that the diversity of models will increase. We may eventually see a car designed for short suburban runs at one extreme and at the other extreme a car built specially for highway cruising.

European cars are fine for European roads and terrain. But they may not be so good here. Certain popular European-made cars are pushed very close to their limit of stability on curves when they are driven at peak speed on our fast highways.

To sell, passenger cars must match customers' pocketbooks. We had 200-hp cars in 1930, but Depression killed them off quickly. Now people can pay for power, and they do so. There's so little interest in lower-power, lower-price engines that six-cylinder models constitute less than 20% of Ford's engine production.

Wind noises from indented windows are a nuisance, now that other noise sources have been so well quieted. The solution is sealed windows, flush with the outer body surface. Their advent depends on air conditioning developments.

Braking Ability Gains

...but highway studies show

F. William Petring
Highway Transport Research Branch, Bureau of Public Roads

Based on paper "Stopping Ability of Motor Vehicles Selected from the General Traffic."

Table 1—Comparison of brake-system application and braking distances from 20 mph for various vehicle types tested in 1942, 1949, and 1955

Vehicle type	Brake-system application and braking distance in feet—								
	15- percentile			50-percentile			85-percentile		
	1942	1949	1955	1942	1949	1955	1942	1949	1955
Passenger cars	21	17	18	25	21	20	42	26	23
Two-axle trucks	28	23	22	40	28	29	64	41	39
Three-axle trucks	40	26	30	54	37	39	81	56	54
Two-axle truck-tractors with one-axle semitrailers	38	30	31	52	39	40	75	53	52
Two-axle truck-tractors with two-axle semitrailers	43	34	35	61	43	42	83	60	52
Three-axle truck-tractors with two-axle semitrailers	49	42	33	61	53	46	82	69	57
Trucks with full trailers (four, five, and six axles)	48	39	39	65	52	54	87	70	66
Truck-tractors with semitrailers and full trailers (five, six, and seven axles)	47	45	41	62	59	53	82	73	67

Table 2—Vehicles tested in 1949 and 1955 capable of meeting Uniform Vehicle Code Requirement, as revised in 1954, for brake-system application and braking distance from 20 mph.

Vehicle type	Requirement for brake-system application and braking distance in feet	Percent of vehicles tested capable of meeting requirement	
		1949	1955
Passenger cars	25	90	92
Very light two-axle trucks	30	76	84
Two-axle trucks other than very light	40	84	84
Three-axle trucks	50	78	80
Two-axle truck-tractors with one-axle semitrailers	50	81	81
Two-axle truck-tractors with two-axle semitrailers	50	73	80
Three-axle truck-tractors with two-axle semitrailers	50	36	64
Trucks with full trailers (four, five, and six axles)	50	44	38
Truck-tractors with semitrailers and full trailers (five, six, and seven axles)	50	22	41

rate of improvement has slowed.

THE improvement in general levels of brake performance was smaller between 1949 and 1955 than it was in the earlier period 1942 to 1949. Only the three-axle truck-tractor with two-axle semitrailer and the truck-tractor-semitrailer-full-trailer combinations showed substantially better braking in both periods.

This finding, based on tests made on vehicles picked from the general traffic in 1955, indicates that the wide range in stopping capacity of the various vehicle types will not be reduced much in the near future. Consequently it must be taken into account in highway design, vehicle regulation, and driver training.

The summary of the 15-, 50-, and 85-percentile values of brake-system application and braking distance for stops made from 20 mph is shown in Table 1. The sample of vehicles of each type is made up of various gross weights, capacities, brake types, and conditions of maintenance.

A slightly more encouraging picture of brake performance is given in Table 2. This gives the percentage of vehicles tested which met the Uniform Vehicle Code for brake-system application and braking distance for stops made from 20 mph. From 38 to 64% of the very largest combination vehicle types and about 80% of the three- and four-axle truck-tractor-semitrailer combinations and three-axle trucks were capable of complying with the Code. Some 84% of two classifications of two-axle trucks and 92% of passenger cars were able to comply with their respective distance specifications of 40, 30, and 25 ft.

The improvement shown by the three-axle truck-tractors with two-axle semitrailers is worthy of special note. In 1942, only 17% of vehicles of this type could stop within 50 ft, the present Code standard. By 1949, the number had risen to 36% and when the 1955 tests were made 64% were able to comply.

One of the most interesting items, classing as incidental information, is the comparative ability of various vehicle types to comply with the deceleration requirements of the Uniform Code. Well over 99% of passenger cars met the deceleration specification of 17 fps per sec. At the same time, all very light two-axle trucks and 94% of other two-axle trucks met their 14 fps per sec requirements. So did 76 to 85% of the truck-tractor-semitrailer combinations and three-axle single-unit trucks, and 51 to 69% of trucks with full trailer, and truck-tractors with semitrailers and full trailers. These data are presented in Table 3.

When these data are compared with those in Table 2 it is revealed that a greater percentage of vehicles of each type could comply with the Uniform Vehicle Code for deceleration than could meet the corresponding specification for brake-system application and braking distances. For this reason, an enforcement program based on the latter would single out more vehicles with unsafe brakes than a program based on the requirement for deceleration. In point of fact, Table 3 shows that enforcement based on deceleration alone would single out only the very poorest of the passenger cars and two-axle trucks.

The observed average levels of brake performance in stops from 20 mph for commercial vehicles, operating in the general traffic with normal loads, was about 25 ft for two-axle trucks with a manufacturer's gross vehicle weight rating of 10,000 lb or

Table 3—Vehicles tested in 1955 capable of meeting Uniform Vehicle Code requirement for deceleration

Vehicle type	Requirement for deceleration in ft/sec²	Percent of vehicles tested in 1955 capable of meeting requirement
Passenger cars	17	99.7
Very light two-axle trucks	14	100.0
Two-axle trucks other than very light	14	93.9
Three-axle trucks	14	85.0
Two-axle truck-tractors with one-axle semitrailers	14	82.7
Two-axle truck-tractors with two-axle semitrailers	14	81.7
Three-axle truck-tractors with two-axle semitrailers	14	76.0
Trucks with full trailers (four, five, and six axles)	14	51.2
Truck-tractors with semi-trailers and full trailers (five, six, and seven axles)	14	69.4

Table 4—Vehicles that slid one or more wheels on stopping. Note that passenger cars and very light trucks were the worst offenders. A large percentage of trucks and combinations that slid was empty.

Vehicle type	Percent of vehicles sliding wheels on— Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	Axle 7	One or more axles
Passenger cars	54	74	—	—	—	—	—	85
Very light two-axle trucks	18	74	—	—	—	—	—	76
Two-axle trucks other than very light	6	48	—	—	—	—	—	51
Three-axle trucks	0	45	48	—	—	—	—	51
Two-axle truck-tractors with one-axle semitrailers	0	26	31	—	—	—	—	40
Two-axle truck-tractors with two-axle semitrailers	1	17	37	45	—	—	—	53
Three-axle truck-tractors with two-axle semitrailers	0	17	18	27	38	—	—	50
Trucks with full trailers (four, five, and six axles)	0	9	7	10	19	3	—	29
Truck-tractors with semitrailers and full trailers (five, six, and seven axles)	0	11	33	22	48	4	4	61

less. These levels ranged from 35 to 45 ft for other two-axle trucks, from 40 to 50 ft for three-axle jobs, from 45 to 55 ft for three-, four-, and five-axle truck-tractor-semitrailer combinations, and finally from 55 to 65 ft for truck-full-trailer and truck-tractor-semitrailer-full-trailer combinations.

The tests also made evident that many commercial vehicles, except for very light two-axle trucks, were inadequately braked in proportion to the loads carried on individual axles. This was shown by the sliding of wheels on making a stop. Table 4 presents the data.

This disproportionate braking may result from insufficient maintenance, from axle loads heavier than those for which the brake components were designed, and poor selection of brake components. Individual tests did prove that vehicles with axle loads as high as 22,000 lb can be adequately braked.

Some swerving was noticed when vehicles made stops from 20 mph. This is dangerous and the hazard is usually increased when the stops are made from higher speeds. Passenger cars and very light two-axle trucks were the worst offenders in this respect as the following comparisons show:

	1942	1949	1955
Passenger cars	20	34	28
Very light two-axle trucks	—	—	29
All two- and three-axle trucks	16	18	14
Two-axle truck-tractors with one-axle semitrailers	12	12	5
Combinations with four or more axles	6	8	4

Although the conditions appears to be improving somewhat, there is room for betterment, particularly in the passenger car and light truck classifications.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Cetane Number . . .

. . . of fuels significantly influences performance characteristics of diesel engines according to a CRC study.

INFLUENCE of fuel cetane number on diesel-engine performance is discussed in a CRC report (CRC-291), "Significance of the Cetane Number of Diesel Fuels." Cetane number is the measure of the ignition quality of a fuel, judged by the length of the delay between fuel injection and ignition. According to these tests, the cetane number is determined by testing a sample of the fuel in a CFR engine in comparison with a mixture of standard reference fuels of low and high ignition quality, under conditions where the test fuel and the reference fuel have the same ignition delay time. This cetane number is significantly related to engine performance characteristics.

Effect on starting: Cetane number of a fuel has a direct influence on ease of starting a diesel engine, since use of a higher cetane-number fuel makes it possible to start an engine at lower air temperatures and/or lower cranking speeds.

Influence on engine warmup: At low air temperatures, rapid warmup, or prolonged engine operation in cold weather at light loads, the cetane number of the fuel has a noticeable influence on engine behavior. The cetane number of the fuel should be chosen high enough to avoid misfiring that can occur under these conditions.

Influence on combustion: Since ignition of the fuel does not occur immediately upon injection, the longer delay period of low cetane-number fuels permits fuel to be injected and changed chemically before ignition starts. This can result in an excessively rapid rise of cylinder pressure, which in turn

may be accompanied by audible combustion knock and increased engine roughness.

However, there is an upper limit beyond which an increase of cetane number is of no practical advantage. Fuels of cetane number appreciably above the engine requirement may not permit sufficient time for the mixing of the fuel with air before ignition. As a result, there may be an increase of the exhaust smoke under full-load conditions.

Effect on power and consumption: For a given volatility, the lowest cetane-number fuel that will permit proper combustion will give the best fuel economy or power output. This is due to the fact that lower cetane-number fuels for a given boiling range have higher heating value per gallon.

Influence on exhaust conditions: Low cetane-number fuels may cause exhaust smoke and objectionable odor due to partial combustion or misfiring cylinders under idling or light-load conditions, particularly during the engine warmup period in cold weather. However, in the intermediate range of loads and speeds, cetane-number effect appears to be overshadowed by other fuel properties.

Influence on deposit formation: The accumulation of carbonaceous or resinous deposits in diesel engines may take place as a result of incomplete fuel combustion. Cetane number of the fuel affects operating conditions in which the available ignition temperatures are below normal; for intermediate loads and speeds, however, other fuel properties have a greater effect on deposit formation.

CRC-291 contains 10 pp. It is available from SAE Special Publications Department. Price: 50¢ to members, $1 to nonmembers.

Airtight Aircraft Wheels

. . . are a "must," now that tubeless tires are being required as standard equipment on practically all new aircraft.

F. D. Swan

Member, SAE Technical Committee on Aircraft Wheels, Brakes, and Axles (A-5)

AIRCRAFT wheels must be airtight, now that tubeless tires are being required as standard equipment on practically all new aircraft. They must be airtight:

- At the joints of divided wheels where the two halves are bolted together, or
- At demountable flanges.
- In respect to wheel castings. Wheel castings of aluminum and magnesium must be of material dense enough to prevent seepage of air through porous spots.
- At machined openings for the valve and part attachment screws in the rim and bead-seat area. These openings must be sealed to prevent loss of air pressure.

Satisfactory methods have been developed to bring about airtightness at all necessary points.

The O-ring type of rubber seal has been found satisfactory to seal between the halves of bolted-together wheels . . . also for sealing the demountable flange type of wheel. The section of the O-ring is confined in a groove machined in the wheel-half and is compressed as the bolts are drawn tight.

A sealing agent—baked and retested for airtightness—impregnated into porous wheel castings of magnesium or aluminum is bringing about necessary airtightness in this area. In the meantime, the current trend toward use of forgings instead of castings is reducing the need for impregnating treatment.

Painting the rim and bead-seat surface with zinc chromate primer and lacquer seems to provide an effective air seal at these points.

Two general types of valves have been used satisfactorily.

The first is a clamped-in type. A rubber grommet surrounding the body of the valve under the head is compressed against a counterbore in the rim surface when a hex nut is drawn up against a washer and counterbore on the underside of the rim.

The second is the so-called tank valve or shock-strut type, which threads into a boss machined for the purpose. Here, a rubber O-ring makes the airtight seal.

Maintenance Problems

Maintenance procedures must avoid damage to any of the surfaces which play a part in retaining air pressure. Such surfaces include flanges, bead seats, surfaces of O-ring grooves, and valve-seat areas.

A change to tubeless tires on older aircraft in service requires new sealed wheels . . . or a modification of tube-type wheels to make them airtight.

Development Problems

Tire companies had more difficulty developing successful tubeless tires for airplanes than for most ground vehicles, to begin with. For aircraft, they were faced with higher operating inflation pressures; greater normal tire deflection under load; and operating temperatures required by the military from −65 F to +160 F.

But the service of aircraft tubeless tires to date has been satisfactory in the limited period of use since the development was originally started in 1951. It is generally agreed today that development of the tubeless tire and sealed aircraft wheel represents a distinct step forward in aviation.

How Chrysler's TorqueFlite Transmission Works

S. D. Jeffe, B. W. Cartwright
Chrysler Corp.

Excerpts from paper "Chrysler TorqueFlite Transmission."

THE Chrysler TorqueFlite transmission (Fig. 1)—a 3-speed unit with torque converter—was designed to meet these objectives:

1. Simplicity of construction resulting in trouble-free operation.

2. High breakaway torque ratio, providing good low- and medium-speed acceleration.

3. Controlled low and intermediate gear ratios, giving adequate engine braking or hill climbing ability for moderate or steep grades.

4. Wide range of ratios, making possible the use of low rear-axle ratios to improve fuel economy.

5. Smooth shifting and quietness of operation.

An understanding of how these objectives were met should be attained by studying the following "HOW's":

1. HOW some of the components are made.

2. HOW the power is transmitted through the gearbox.

3. HOW the hydraulic controls operate.

4. HOW the transmission itself operates.

Components

Torque Converter—The torque converter is a single-stage, 3-element unit containing an impeller, a turbine, and a single stator, as shown in Fig. 2.

The turbines and impellers employ stamped blades, which are spot-welded to stamped inner shroud and, in turn, hydrogen-brazed to their individual shells. The stators are die-cast aluminum employing an internal overrunning cam riveted in place. The remainder of the overrunning unit, which is incorporated into the stator, includes eight individually energized rollers and a splined free-wheeling hub, which mounts on the reaction shaft. The front cover, which is mounted rigidly to the

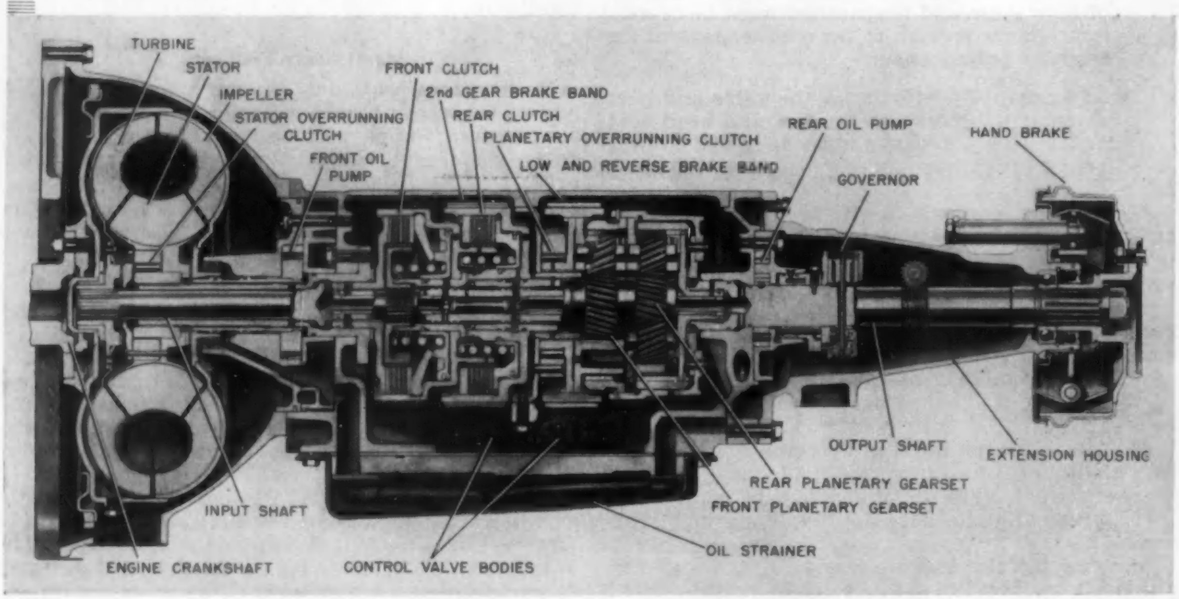


Fig. 1—Chrysler TorqueFlite transmission is a 3-speed unit with torque converter.

crankshaft, is fastened to the impeller by means of a submerged arc-weld about the periphery of the converter.

The three converters available with TorqueFlite are:

1. An 11¾-in. diameter, 2.6 stall torque ratio, air-cooled converter employed in the Chrysler Windsor; water-cooled in the Chrysler Saratoga.

2. An 11¾-in. diameter, 2.7 stall torque ratio, air-cooled converter employed in all other V-8 installations, except the 392 cu in. V-8.

3. A 12½-in. diameter, 2.3 stall torque ratio, water-cooled converter employed for all 392 cu in. engine installations.

Performance curves for the third of these—the 12½-in., 2.3 stall torque ratio converter—are shown in Fig. 3.

Both of the 11¾-in. diameter units were available with the PowerFlite transmission, but the 12½-in. diameter converter was developed specifically for the TorqueFlite application. The 11¾-in. diameter converters could further improve car performance with the large engine, but are not used because of the greater torque capacity requirements of the transmission as well as excessive wheel skid characteristics with these smaller converters.

The new 12½-in. diameter converter was designed to reduce excessive peak torques that the transmission must handle, but still provide increased performance compatible with engine overrun. The low-speed peak input torque has been reduced with the new torque converter, but the higher torque available in the midrange provides a net gain in overall vehicle performance as compared to the 12½-in. diameter converter previously used with the PowerFlite.

Gear Train—The gear train is designed such that both sets have the same numbers of teeth and identical gear data (Fig. 4). The annulus gears have 66 teeth, the planet pinions have 18 teeth, and the sun gears have 30 teeth. The gear teeth are 14 diametral pitch with a 20-deg helix angle and a 20-deg normal pressure angle.

Since both sets are the same, the planet pinions, the carriers, and the planet pinion shafts and needles are interchangeable. The sun gears are both hobbed on a single forging. The annulus gears are made from steel tubing, which is broached to produce the tooth form. This broaching operation on the annulus gears has resulted in a saving in both part and tooling costs.

Rolled Splines—The use of a rolling operation to form the involute splines on the input and intermediate shaft has proved very satisfactory. Manufacturing time for these operations has been reduced from approximately 4½ min to only 13 sec for the finished spline. The same procedure is used to form the speedometer worm gear, which is integral with the output shaft.

Torque Converter Reaction Shaft—The torque converter reaction shaft (Fig. 5) is made from an aluminum impact extrusion. This method of fabrication has eliminated all semifinishing operations and requires only five operations for a finished part. This shaft must carry torque converter reaction torque and its strength has proved to be adequate

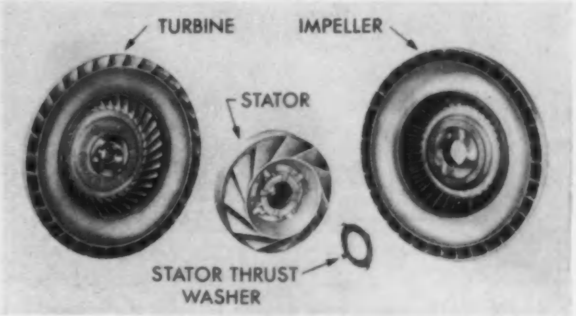


Fig. 2—Torque-converter components.

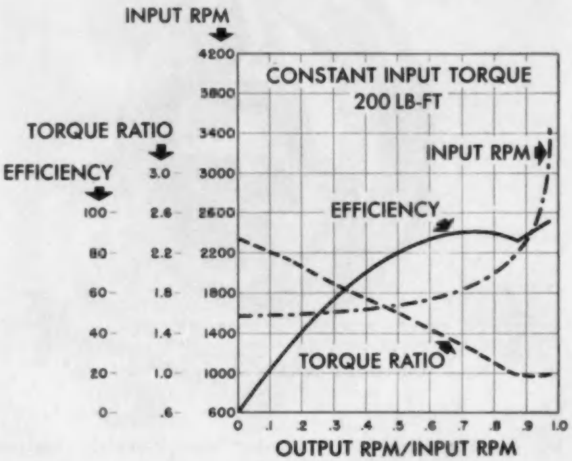


Fig. 3—Performance curves for 12½-in., 2.3 stall ratio converter.

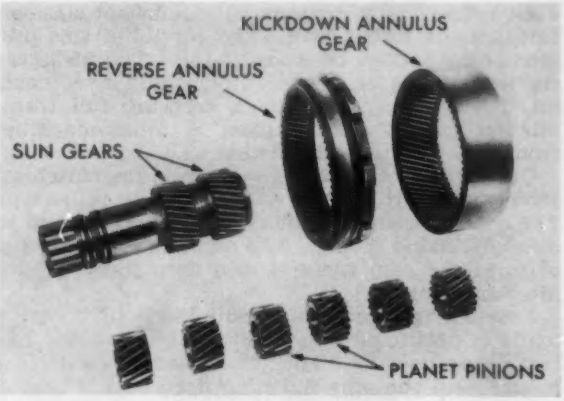


Fig. 4—Gear train components.

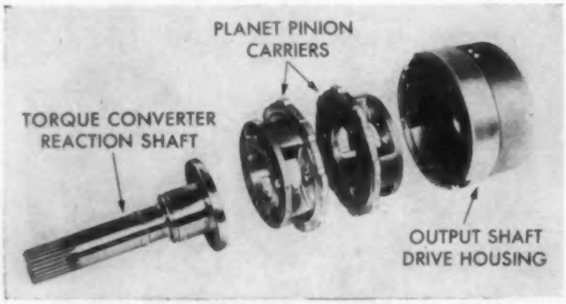


Fig. 5—These power train members are made of aluminum.

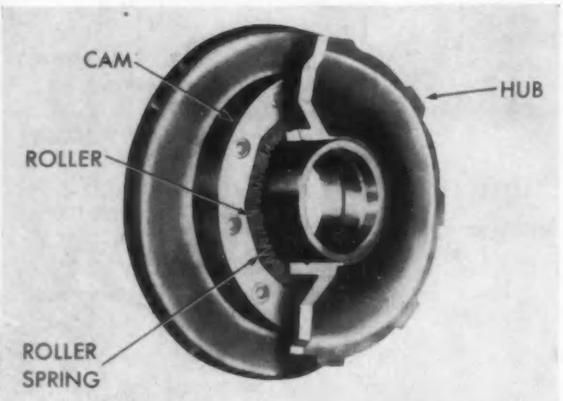


Fig. 6—Overrunning clutch is of cam and roller type.

by cycling the shaft under considerable torque overload.

Planet Pinion Carriers—The planet carriers are identical aluminum die castings. Only six machining operations are required to finish the part. Considerable development work was necessary to produce a design in aluminum with sufficient strength to carry the torque load. The results of this program have indeed been gratifying. The kickdown carrier is mounted in the output shaft drive housing. This housing, although carrying full transmission output shaft torque, is finish-machined from an aluminum die casting.

Overrunning Clutch—The overrunning clutch assembly shown in Fig. 6 is of the cam and roller type. The unit contains 10 rollers, each of which has its own energizing spring. The outer race is broached to form the cam surfaces and then finish-ground after hardening.

Rear Pump Gear—The rear pump outer gear is made of plastic and operates in an aluminum die-cast pump housing. The gear is accurately molded to size, and the only finishing operation is that of grinding to the desired thickness. Considerable development time was spent in finding a plastic which could withstand the effect of type A oil at elevated temperatures without excessive growth or wear.

Front Clutch Levers—The operating levers in the front clutch assembly are interesting, not only from a manufacturing, but from a design viewpoint as well. The initial design utilized eight flat-steel stampings to apply the multiple-disc clutch and, due to a characteristic of decreasing lever ratio as piston travel increased, five friction discs were required. The latest refinement of this design (shown in Fig. 7) utilizes only four levers with a shape that provides a constant lever ratio, regardless of piston travel. Since the lever ratio remains constant, it was possible to reduce the number of friction discs to four, with a subsequent cost saving. The levers are made from powdered metal and require no machining.

Power Flow

Each driving position is reviewed here to show how the power is transmitted through the gearbox.

Drive: Breakaway (Fig. 8)—The power flow is from the torque converter turbine through the input shaft and front clutch retainer. The front clutch is engaged and the power is transmitted through the front clutch hub and intermediate shaft to the kickdown annulus gear. The annulus gear drives the kickdown planet pinions, which rotate the sun gear in a reverse direction. The sun gear rotates the reverse planet pinions forward and thereby produces a forward rotation of the reverse annulus. The reverse planet carrier is prevented from rotating backwards by an overrunning clutch, which becomes stationary during breakaway. The reverse annulus and kickdown planet carrier combine in the output shaft drive housing to rotate the output shaft forward and produce a torque ratio of 2.45/1. For low-range operation (Fig. 9), the overrunning clutch is locked out by the low band.

Drive: Second Operation (Fig. 10)—The power flow is from the torque converter turbine through the input shaft and front clutch retainer. The front clutch is engaged and the power is transmitted through the front clutch hub and intermediate shaft to the kickdown annulus gear. The kickdown band is applied and holds the sun gear stationary. The kickdown annulus gear causes the planet pinions to rotate forward, forcing the planet carrier in the same direction. The kickdown planet carrier is splined to the output shaft drive housing and rotates the output shaft in the same direction, producing a torque ratio of 1.45/1.

Drive: Direct (Fig. 11)—In direct drive both clutches are engaged and locked together. Since the kickdown annulus gear is connected to the front clutch through the intermediate shaft, and the sun gear is connected to the rear clutch, the kickdown planetary unit is locked, and the entire planetary system rotates as a unit at input shaft speed. This produces a torque ratio of 1/1.

Reverse (Fig. 12)—The power flow in reverse is from the torque converter turbine through the input shaft and the rear clutch retainer. The rear clutch is engaged and the power flow is through the rear clutch retainer and sun gear. The sun gear drives the reverse planet pinions in the reverse direction. The reverse planet carrier is held by the action of the low and reverse servo and band, and the planet pinions drive the reverse annulus gear in the reverse direction. The reverse annulus gear, being splined to the output shaft drive housing,

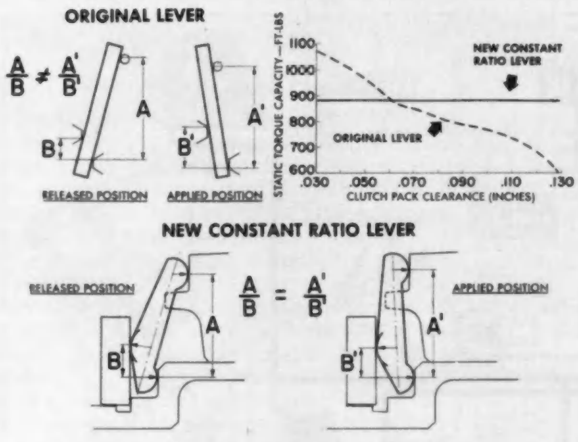


Fig. 7—Front clutch lever operation.

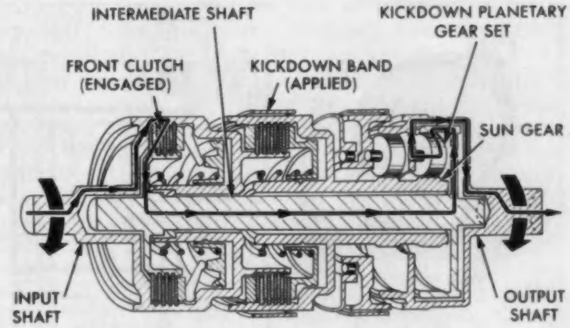


Fig. 10—Power flow—second.

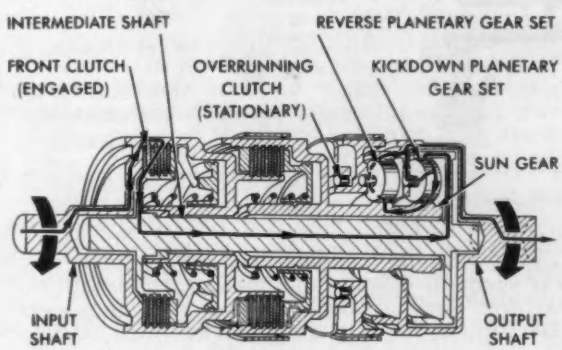


Fig. 8—Power flow—breakaway.

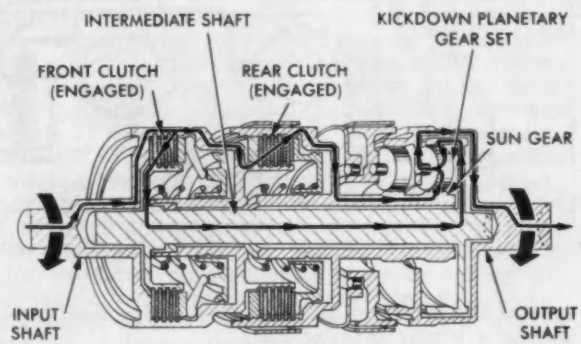


Fig. 11—Power flow—direct.

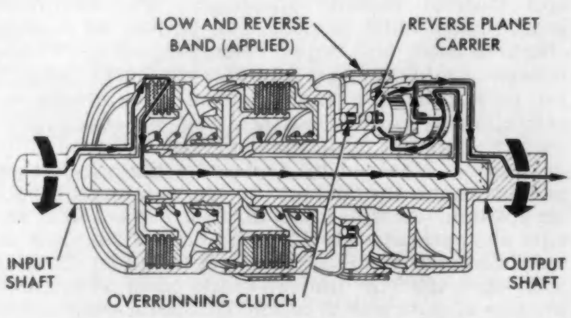


Fig. 9—Power flow—low.

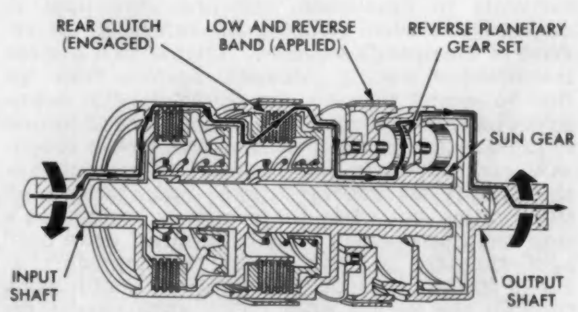


Fig. 12—Power flow—reverse.

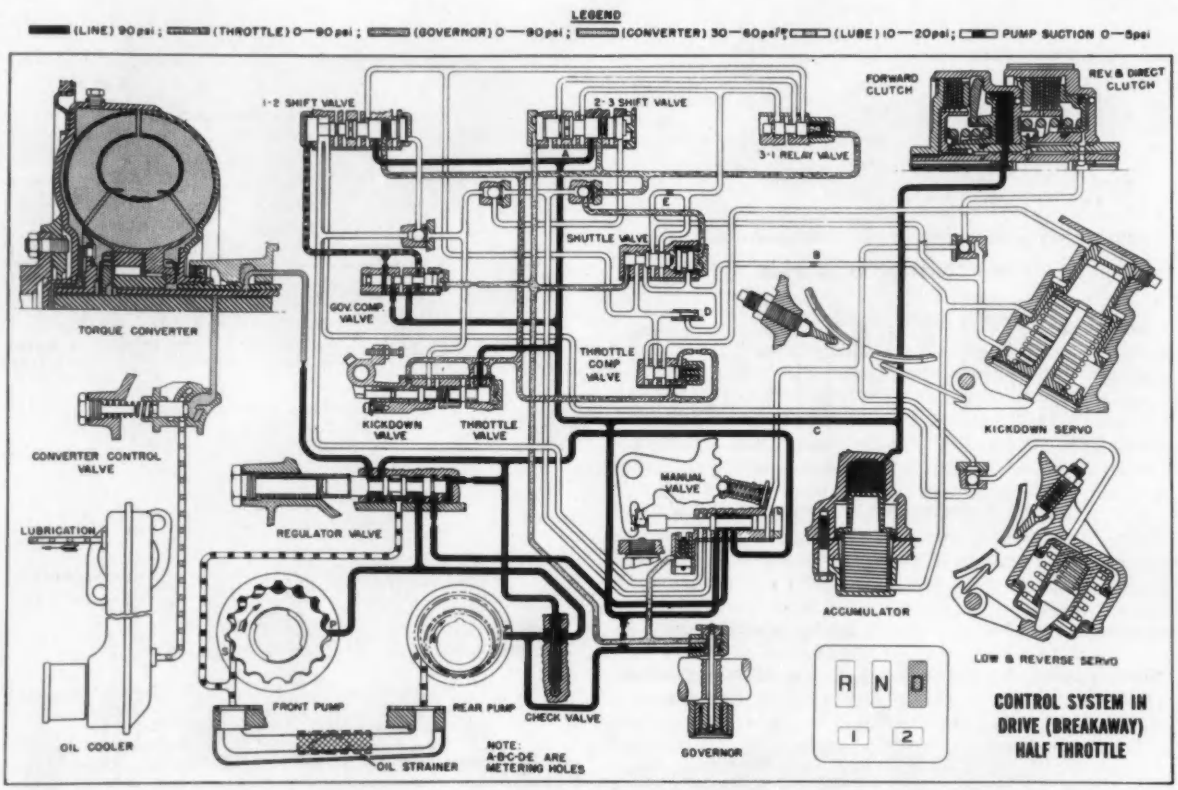


Fig. 13—Hydraulic circuit—breakaway.

rotates the output shaft in a reverse direction, producing a torque ratio of 2.2/1.

Hydraulic Controls

Fig. 13 shows a diagram of the TorqueFlite hydraulic control system in drive ("D") breakaway.

The hydraulic controls of the transmission have some unique features worthy of mention:

3-1 Downshifts—In most automatic transmissions currently in production, the procedure used in downshifting when stopping the vehicle is the reverse of the upshift sequence. That is, in a 3-speed transmission making automatic upshifts from the first to second to third, the closed-throttle downshifts have been made from third to second to first in rapid sequence, with resulting undesirable roughness and noise. In the TorqueFlite transmission, the upshift sequence in "drive" range utilizes all three ratios, but when the vehicle is brought to a stop, the transmission remains in direct drive until approximately 10 mph, when the downshift at closed throttle is made to low gear without passing through the second ratio. This arrangement results in an imperceptible downshift because the overrunning clutch free-wheels and completely eliminates any objectionable bumps or noise. The direct-to-low downshift is accomplished by the 3-1 relay valve, which coordinates the movements of both shift valves.

Shift Pattern—Considerable development effort was spent in establishing the most desirable shift pattern. Several modifications were made to experimental units to vary the speed at which shifts occurred for a given throttle opening, and these units were evaluated by various corporation personnel to establish their preference. In general, they seemed to prefer a shift pattern that places the transmission into direct ratio as early as possible at light and medium throttle openings. The maximum performance shift pattern was limited by engine characteristics and noise. The TorqueFlite transmission control system provides an early pattern for normal driving and what we have chosen to call a "delayed shift pattern" for situations that require optimum performance. The "delayed shift pattern" is obtained by depressing the accelerator pedal through the "detent" to the wide-open throttle position. At wide-open throttle, the 1-2 shift occurs at approximately 40 mph and the 2-3 shift at approximately 70 mph. At the detent, just short of wide-open throttle, the two shifts occur at approximately 25 mph and 55 mph. This arrangement has met with the widespread acceptance of all who have taken the wheel of a TorqueFlite-equipped car.

Kickdown Control—The use of the shuttle valve for control of kickdown quality in the PowerFlite has proved successful. This valve was retained in the TorqueFlite controls with certain refinements

to provide for smooth engagement of the kickdown band during forced 3-2 downshifts. Below approximately 30 mph, the TorqueFlite will kickdown into low gear, and the overrunning clutch provides a smooth transition without the need for additional hydraulic controls.

Transmission Operation

The TorqueFlite transmission provides, along with neutral, three forward driving ranges and reverse. The gear ratios are obtained through the two compounded planetary gear sets and are controlled by the two multiple-disc clutches, the two bands, and the overrunning clutch. As on the PowerFlite, the complication of a parking position is eliminated through the use of the powerful internal expanding hand brake mounted on the rear of the transmission extension. The hand brake, which is completely independent of the wheel brakes, is a standard feature on our cars equipped with automatic transmissions.

In general, our cars equipped with this transmission contain axles one ratio numerically lower than previous models. A 12½-in. diameter water-cooled torque converter is used with the 392 cu in. engine installations. All other powerplants use 11¾-in. diameter torque converters.

Five pushbuttons are used to select the driving ranges. In addition to neutral ("N") and reverse ("R"), three forward driving ranges are provided:

"D"-Drive—In this position, the transmission always starts in first gear and automatically upshifts into second and direct. Kickdown into second gear is possible below 65 mph, and into first gear below 30 mph. A closed-throttle downshift from direct to first gear occurs at 10 mph.

"2"-Second—In this position, the transmission always starts in first gear and automatically upshifts into second. It will remain in second, regardless of throttle opening, until 70 mph, at which time it will upshift into direct to prevent overspeeding the engine. Kickdown into first gear is possible below 30 mph. A closed-throttle downshift from second to first occurs at 10 mph. The provision for second gear operation allows greater drive control in city traffic and hilly terrain.

"1"-First—In this position, the transmission starts and remains in low gear regardless of car speed and throttle opening. If this position is selected at speeds above 30 mph and below 65 mph, the transmission downshifts into second immediately and will remain in second until the vehicle speed falls below 30 mph, at which time it will downshift into first gear. This is a two-way drive gear position.

All of the shift speeds referred to are approximate values for a Chrysler New Yorker car with 3.18 axle. The progression through all three gears in "drive" operation obviously results in two automatic upshifts. The upshift from first to second involves a transition from an overrunning clutch to a band. The upshift to direct is completed by the transfer from a band to a clutch in a manner similar to the present PowerFlite upshift. The incorporation of the overrunning clutch has greatly improved the operation of this transmission. During the 1-2 upshift, the overrunning clutch remains engaged until the kickdown band has gained sufficient torque capacity to carry the load; at that time a torque reversal occurs on the "low" reaction member, thereby causing the overrunning clutch to free-wheel at precisely the proper instant. The transient capacity of the band is controlled by the kickdown piston and an accumulator. If friction material had been employed as a "low" reaction, the control of the shift would become considerably less accurate. The normal 3-1 downshift involves the transition from the direct clutch to the overrunning clutch. Since this downshift normally occurs at closed throttle, the "low" reaction member will rotate forward, causing the overrunning clutch to free-wheel and thereby permits an imperceptible downshift.

A forced downshift from 3 to 1 or 2 to 1 is also aided by the overrunning clutch. Good quality in this shift can only be maintained by proper engagement timing of the oncoming element. In the TorqueFlite, the overrunning clutch will always automatically engage at precisely the instant when the engine has made the proper speed change to correspond to the new ratio. In this manner, an extremely smooth kickdown is accomplished.

(Paper on which this abridgment is based is available in full in multilith form from SAE Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

Electrical Systems . . .

. . . are expected to do more jobs for the motor truck. There is also a need to make them more reliable.

Based on paper by **G. W. Hostetler,** International Harvester Co.

A LOOK at electrical trends in motor trucks reveals a steady increase in demand for heavy duty systems and a need for greater reliability.

The demand placed on systems was reflected first in greater battery capacity, more recently by a raising of generator capacity, and now the move is toward increased sparking voltage and cranking torque. This pushes the 12-v system to the fore.

Higher compression ratios require higher firing voltages and the swing from six to eight cylinders means a decrease in the time available for the ignition coil to build up its magnetic field for spark production. Voltage buildup has been bitten into further by the trend to higher engine speeds. A double breaker point distributor offers adequate relief, but involves a cost and service penalty. The 12-v system also provides a sometimes needed bonus in ignition for cold starting.

A magneto is an effective secondary voltage generating device, but it is more costly than the distrib-

utor-coil system, and it offers no provision for part-throttle, vacuum-sensitive spark advancement. Ignition systems other than the high tension coil and distributor have been tried. Still under study are radio frequency voltage generation, the Vander-Graff generator, and a low tension distribution system. Only the last has emerged from the laboratory for truck use.

Cranking torque demand is also on the increase. Compressed air starting motors can provide high torque and high cranking speeds, but short available cranking time, high cost, and space and weight penalty for air storage militate against their adoption. The trend is rather toward making the entire system 24-v.

The 24-v system is favored over the series parallel 12-24v system because the series parallel switch is expensive and troublesome. The "balanced" 24-v system, which provides 24v for cranking and 12v for all else, is sound in theory, but few people know how to balance them properly and the circuit wiring is complex.

The military is standardizing on a negative ground system and this, together with the SAE approval, will probably bring about wide adoption.

Lighting demands are heavy. On a tractor, semi-trailer, and full trailer combination, lighting regulations may call for as many as 62 lamps. This gives a steady night time load of about 45 amp at 6v. Stop lights, turn signals, and other occasional loads add up to about 31 amp, and there are still more lamps one could install.

The demands on wiring are to give better protection in the form of cabling; better looming and clipping of long runs; and resistance to abrasion, mud, and ice. This will come when customers demand it and are willing to pay for it in the interest of cutting service costs.

Two-way radio is coming in for fleet control. This creates a demand for the low cut-in speed generator. The ac system is very useful where load is high, especially at low engine speeds. TV has brought a demand for better suppressing of radio interference generated by the high tension system and various arcing contacts. Cab air conditioning seems destined to expand. With cabs already crowded, this bit of equipment may have to go on the cab roof, placing further demands on the electrical system.

Standby electrical power is good as long as it is balanced in standby capacity by battery size and in power requirements by generating capacity. Here, low speed, cut-in generators can be used to carry the load and decrease standby capacity. We can only take out what we put in and the handling fees of a battery are high. It takes 25% more power to recharge a battery than it does to supply the same load direct from the generator. In this connection, the nickel-cadmium battery shows interesting characteristics. It has long life and can absorb electrical and mechanical abuse, but cost still limits its application.

Great strides have been taken in the direction of longer life, more power, and greater efficiency of electrical components, but most of the gain has been consumed by increased demands. Too many dollars, too much service time, can be charged to the electrical system. In contrast with an engine valve life of about 75,000 miles (even in heavy-duty service); engines running 100,000 miles without major overhaul and having a 500,000-mile life; we get no more than 15,000 miles of trouble-free life from turn signals, 14,000 miles from clearance lamps, and 13,000 miles from tail lamps. Electrical system parts, not consumed like spark plugs and breaker points, must give 100,000 maintenance-free miles to keep up with the procession. (Based on paper "Electrical Trends in Motor Trucks," which is available in full in multilith form from SAE Special Publications Dept., 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Tabulating Equipment . . .

. . . in Tool Control can cover progress, inventory, and accountability; and produce data within 48 hr of being current.

Based on secretary's report by **E. J. Hall,** Lockheed Aircraft Corp

IN applying tabulating equipment to tool control, all factors should be considered, including volume, cost, and time. It is dangerous to introduce too large a program at one time.

Tabulated reports may cover three areas:

1. Progress
2. Inventory
3. Accountability

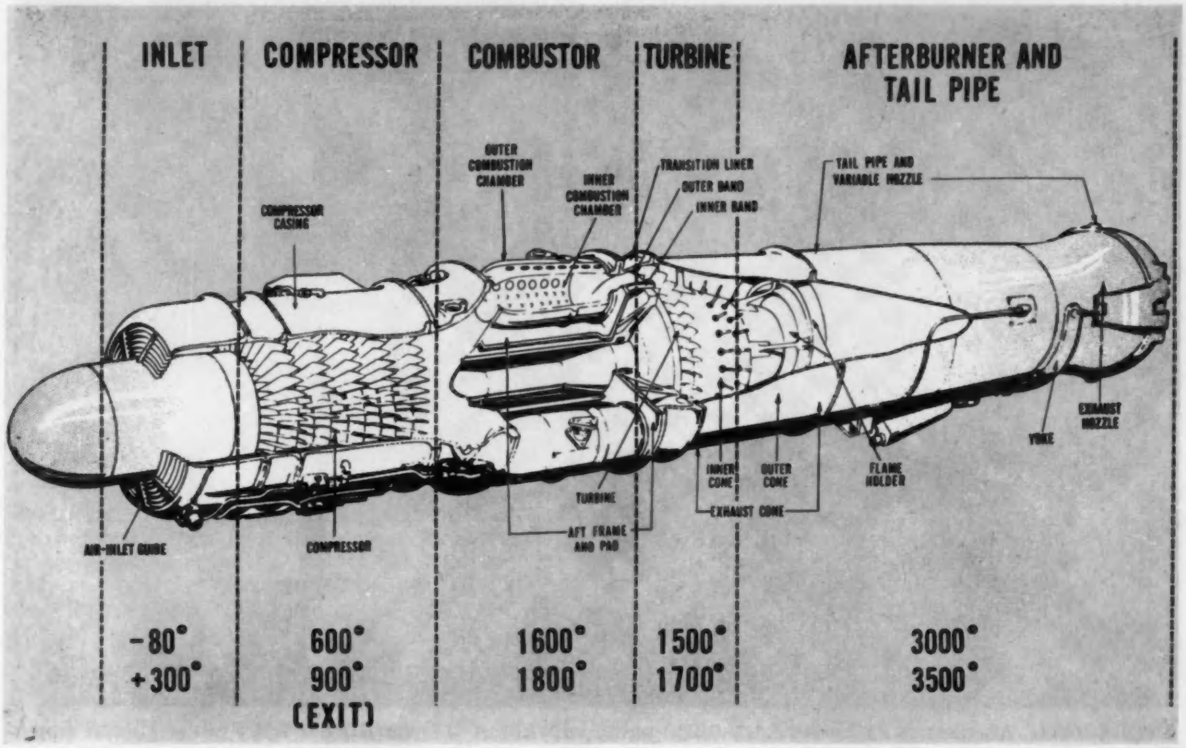
As used in one aircraft plant, the start and due dates as well as the making department actual and estimated hours are shown. From this are produced tabulated lists by shop, start date, etc. This information is used for follow-up. Weekly status and closeout reports are prepared and, from the extended daily hours shown, bar charts are developed.

For inventory purposes a tab card is sent to the crib before the tool is completed. Disposition of inactive tools is made by running the deck through the active parts section.

An accountability deck is maintained for history purposes. It provides information pertaining to ownership, customer code, and sales history, and is useful in handling contract terminations and estimating future programs.

These data produced by tabulating equipment are available within 48 hr.

(This article is based on the secretary's report of panel on "Tool Control." This report together with 14 other panel reports is available as SP-313 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $2.00 to members, $4.00 to nonmembers.



High-Temperature Brazing Proves OK for Jet Engines

John V. Long, George D. Cremer, and Richard S. Mueller
Solar Aircraft Co.

Based on paper "High-Temperature Brazing of Gas Turbine Components."

HIGH-TEMPERATURE brazing is being used more and more in the assembly of gas turbine components subjected to high stresses and high temperatures. There are good reasons for this increasing popularity. Some of them are:

1. It can be applied to complex and multicomponent assemblies.

2. It can give precision production tolerances.

3. It can be applied to extensive joint areas or joint lengths.

4. It can provide natural braze filleting, giving good stress distribution and fatigue resistance.

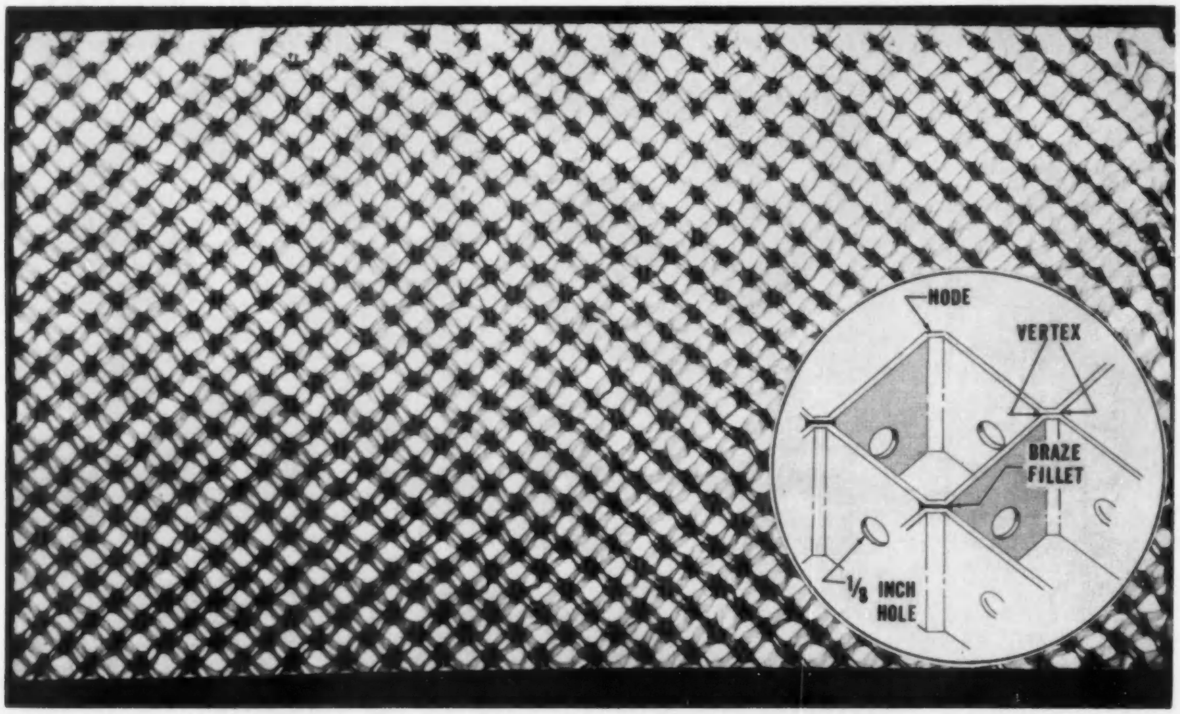
5. It can preserve protective metal coating or cladding.

6. It can be used to join cast materials to wrought materials.

7. It can be used to join widely dissimilar metal thicknesses.

8. It can be used to join dissimilar metals.

On the following pages will be found some examples of where this versatile technique was used to produce high-temperature brazed assemblies of turbojet-engine components.

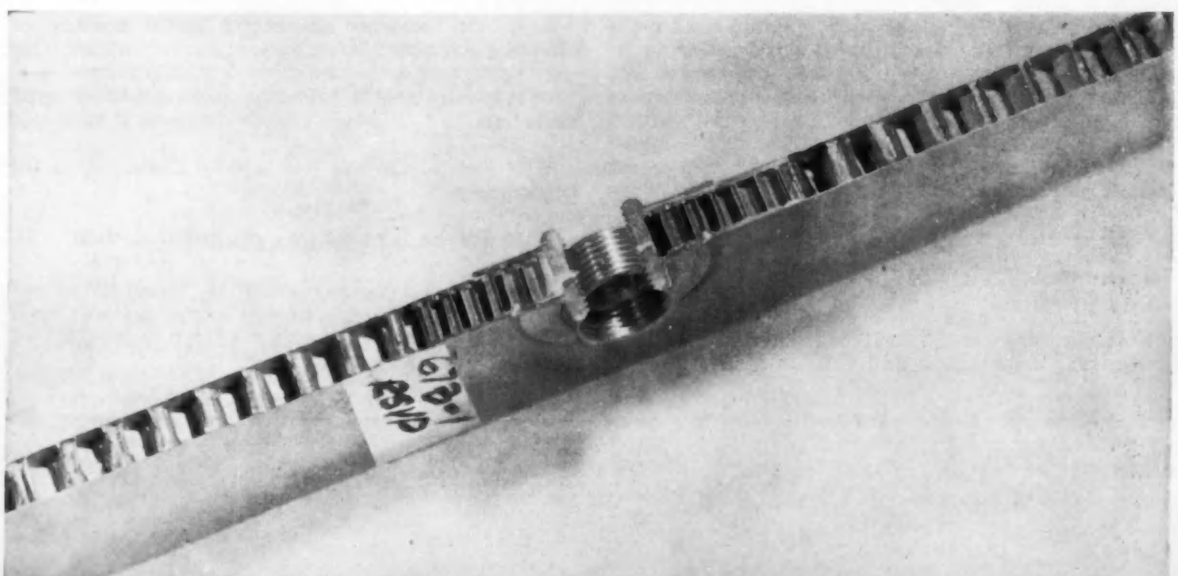


ANTI-ICING. An essentially hollow, structural panel capable of transmitting a hot fluid is shown above. This panel may be used in inlet duct and frontal areas to provide skin heating to prevent ice formation. In this X-ray photograph a perforated honeycomb core is seen to be braze joined to cover or facing sheets, thereby resulting in integral sandwich-type construction. The honeycomb core is an AISI type 321 stainless steel, 0.002-in., ¼-in. square cell, ½-in. thick with ⅛-in. perforations. The facings are 0.020-in. type 321 stainless steel.

Close inspection reveals a high degree of braze flow with excellent bonding of edge channels and core ends. The black parallel "sticks" represent braze filleting at each node vertex where very favorable capillary conditions exist. This X-ray is typical of high-temperature-brazed honeycomb sandwich when radiographic exposure is at an angle oblique to the panel.

COMPRESSOR CASING. One method of securely positioning movable stator vanes in a stainless-steel honeycomb sandwich compressor casing is shown below. Note that a massive, machined boss has been high-temperature brazed into a high-density, high-strength honeycomb sandwich casing. In this manner a practicable method is achieved for distributing concentrated loads into the basic casing structure.

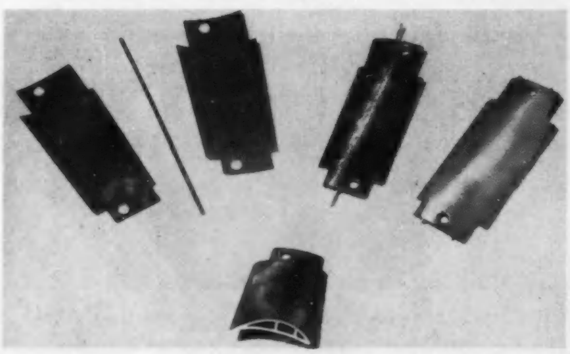
The so-called double brazing procedure has been used. The entire casing consisting of high-density and low-density sandwich is first laid up and assembled by brazing. The structure is then sized and bored to receive the numerous machined bosses. Next a second brazing operation unites the complete assembly.



COMPRESSOR STATOR RING. Brazing techniques are being widely used to fasten the large number of blades at one or both shroud rings in compressor stator assemblies used in axial-flow gas turbines. An experimental 11-in. stator ring fabrication sequence is shown above. AISI 410 roll-formed blades are assembled by staking to the type 321 shroud rings. Small lugs are also spot tacked at this time. A high-temperature furnace brazing operation produces a precision assembly within ± 0.005-in. flatness and concentricity, and capable of standing severe fatigue.

In this particular type of assembly, it is desirable to place brazing alloy at the blade extremities. Braze flow then ensures small, clean fillets on the aerodynamic surfaces.

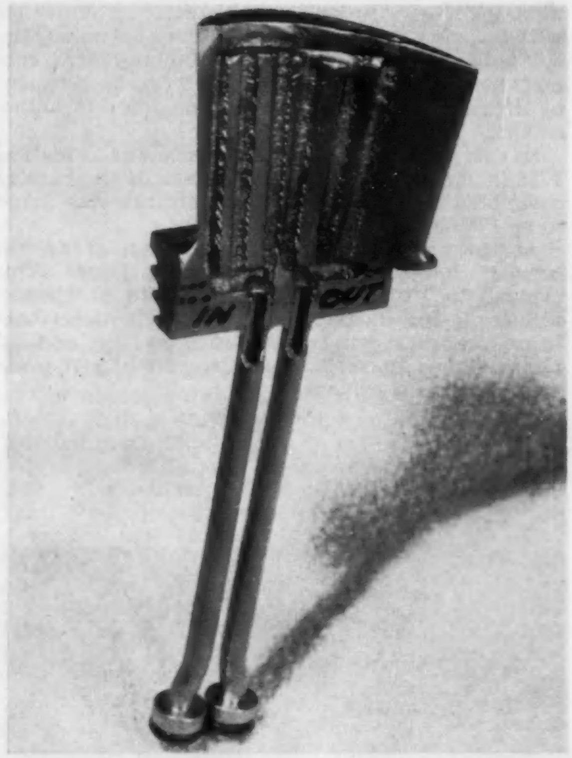
HEAT EXCHANGER. Here we have a cross-flow heat exchanger. High transfer coefficients are obtained by the foil-thin corrugations intimately braze bonded to separating plates. The marcel or corrugated foil is 0.005-in. type 321 in ⅛-in. spacing. Separators are 0.010-in. type 321. Measurement of high-temperature-braze fillet length reveals the surprising figure of 3.84 miles per cu ft of core matrix. This is descriptively called braze "mileage factor."



COMPRESSOR STATOR BLADE. This photograph shows the components that, when brazed together, form accurate, hollow blades. This sheet metal approach permits efficient production of a lightweight, stiff blade. In addition, it also provides means whereby aircooling could be used.

Specific material for the two-piece shell and spars is Timken 17-22A, a high-strength, low-alloy steel. Brazing alloy is nickel base with a flow point of 1850 F. It has been possible to effect brazing and austenitizing heat-treatment simultaneously.

Following the high-temperature furnace brazing and tempering, only a light abrasive buffing is required to produce the finished part.



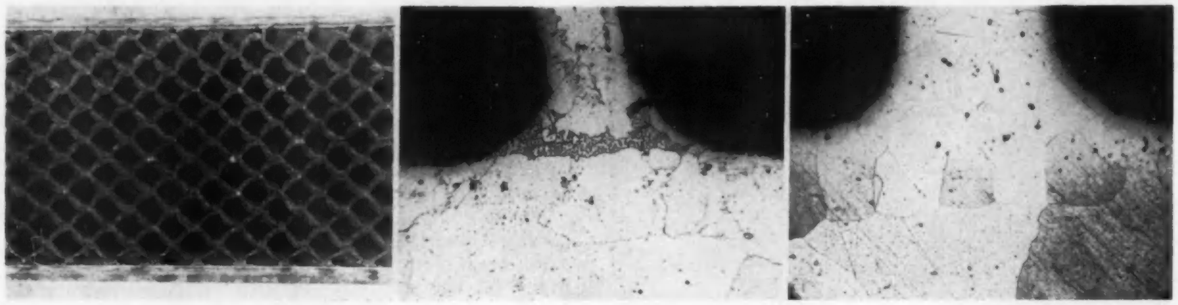
TURBINE BLADING. Shown above is the sectioned blade for a 3-stage, water-cooled turbine rotor. This experimental unit has 149 blades. Brazing was used to join and seal the tip cap, side plugs, and the coolant tubes.

The 0.060-in. thick tip cap is high-temperature brazed into the recessed blade tip. This cap closes the coolant hole access cavity and thus creates in effect a manifold chamber.

Blades are investment cast from Cr-Mo-V high-strength, low-alloy material.

Chromizing has been used successfully to provide oxidation, corrosion, and erosion resistance. Brazing is done after the diffused chromium coating has been applied.

Room-temperature, hydrostatic pressure testing up to 30,000 psi has served to establish optimum brazing conditions. A 20,000-psi acceptance check is used.



TURBINE RUB RING. A portion of an open-face-sandwich experimental rotor tip rub ring is shown at the left. This self-fitting rub ring is designed to allow the rotor to be run with zero tip clearance without hurting the blade. As may be noted, the 0.004-in. gage ⅛-in. square cell honeycomb core ends have been smeared over. This has been caused by direct contact with the turbine rotor in actual service.

In this particular case interference was as high as 1/32 in., yet no galling or unbalance of the turbine rotor blades resulted. Gas temperature was found to be 1750 F.

At the center is a photomicrograph of an "as brazed" honeycomb core-to-backing joint. This typical "tee" type joint comprises 0.004-in. Inconel foil to ⅛-in. Inconel backing. High-nickel-base braze material can be identified as the nodular phase. Some interdiffusion of base metal with braze metal is already evident.

Prolonged heating of such a high-temperature-brazed joint brings about a a very significant and useful phenomenon. Shown at the right is a representative joint that has been dynamically cycled in and out of an air furnace at 1800 F for 88 hr.

Complete homogenization of the brazed joint has occurred. Diffusion and grain growth have eliminated visual evidence of the braze alloy phase entirely. Note the uniform grain structure of the fillets and the micro porosity principally at the grain boundaries.

Such a high-temperature-brazed joint, even though originally brazed at 1980 F, would exhibit outstanding strength up to perhaps 2200 F. A controlling factor for a given brazing alloy is simply the relative initial amount of base metal to braze metal.

It is this fact that, when properly understood and applied, will permit high-temperature brazed sheet-metal structures to operate at all temperatures as efficiently as the base metal itself.

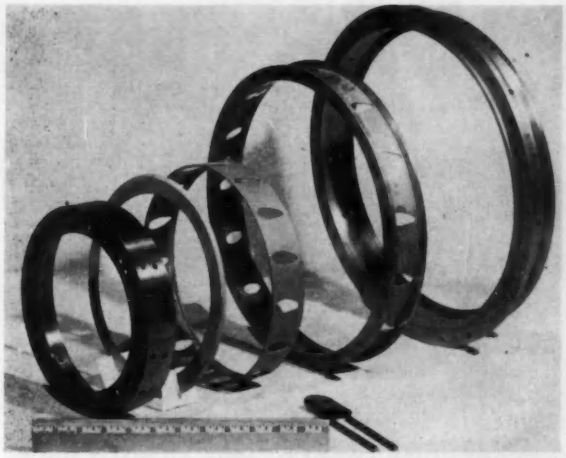
FILLED HONEYCOMB CORE. An important modification of the rub ring application involves filling of the exposed core cells with various materials. Shown above is an enlarged view of a special sintered-metal-ceramic mixture embedded in a 0.005-in. brazed core network. The purpose here is to provide a relatively smooth wear face which is strong yet friable and nongalling. Note the precision honeycomb cell geometry; each node joined by uniform braze metal fillets.

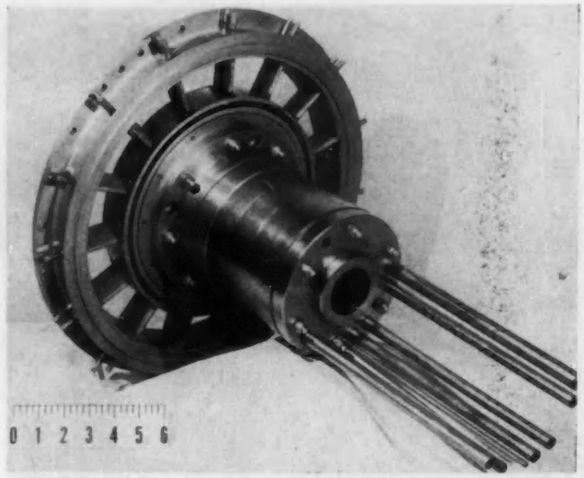
TURBINE ROTOR BLADE. Here is a large, low-pressure turbine rotor blade. This giant measures 17 in. overall and, as the photograph shows, has a high thickness ratio.

A single folded and formed sheet of tapered Inconel X constitutes the skin. Three ribs and an end closure (not shown) are resistance spot welded to the skin. The trailing edge is also held close by spot welds. No fixturing is required during high temperature brazing at 2060 F, as the sheet-metal assembly is inherently very stiff.

After brazing of ribs and trailing edge, the blade is fusion welded to a base assembly and then heat-treated.

This part exemplifies an efficient design requirement for maximum strength/weight at an operating temperature of about 1300 F.





TURBINE AFT BEARING SUPPORT. Components for the high temperature-brazed shroud ring are shown above (left). Aircooled sheet-metal struts are brazed to outer and inner type 502 chromized shroud rings. After assembly (above right) the spoke pairs are braze joined to the massive outer and inner flanges, which are machined from low-alloy forgings.

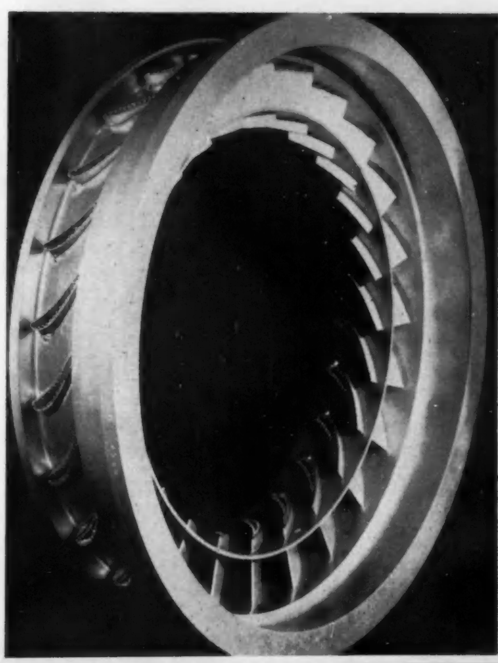
This complex, multicomponent assembly emphasizes desirable features of the high-temperature furnace brazing process.

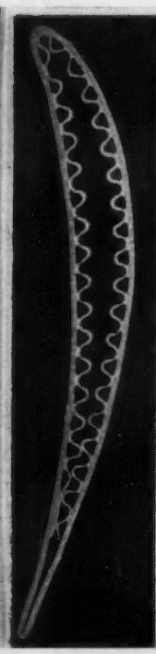
TURBINE NOZZLE DIAPHRAGM. An interesting brazed assembly is presented below (left). Twenty-four pre-brazed turning vanes are fusion tack-weld positioned between a heavy outer flange and a 0.067-in. inner shroud ring. This assembly is then integrated during a second high-temperature-brazing operation.

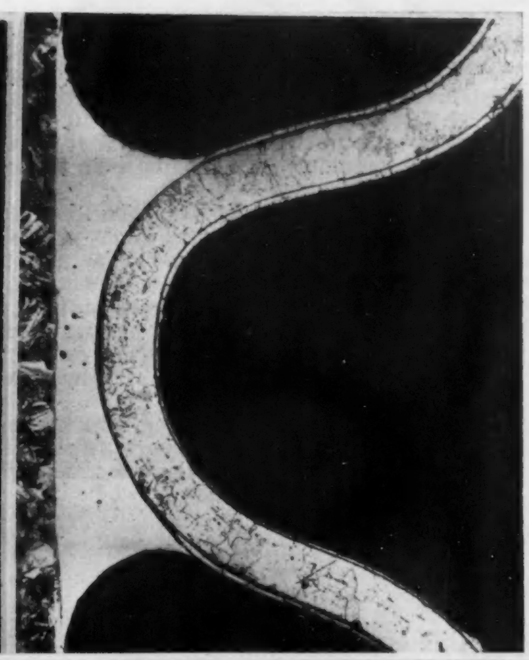
A marcel or corrugated sheet metal insert within each vane may be observed. Cooling air forced over and through this marcel serves to keep the low-allow steel vanes at acceptable temperatures. At the center is a macrophotograph of a sectioned and etched vane. Close inspection will reveal that excellent braze bonding has occurred between the 0.010-in. marcel (AISI 1010) and 0.025-in. NAX vane. Of added significance is the fact that both marcel and vane were separately chromized prior to assembly and brazing. Minute spot welds served to position the marcels within the vanes and insure metal-to-metal contact during the brazing operations.

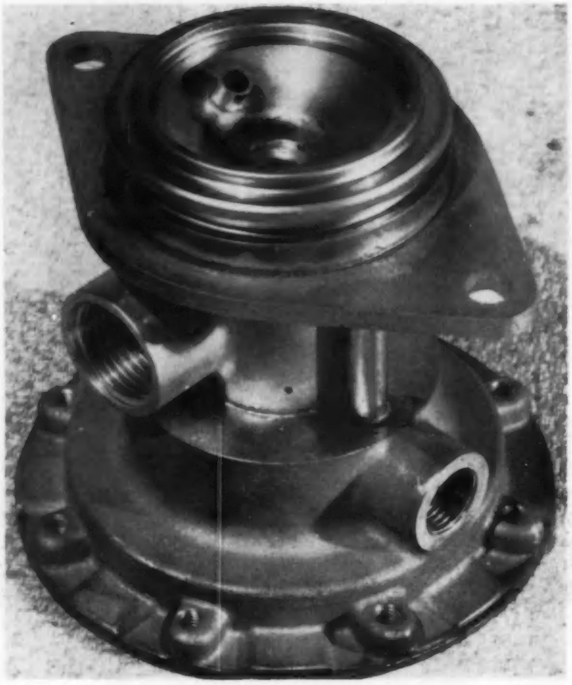
Further magnification of a typical marcel-to-vane joint is shown in the photomicrograph (at the right). The oxidation-resistant chromized diffused layer is continuous up to the braze fillet areas. During brazing, the chromium-rich layer largely dissolves where in contact with the molten braze alloy. Oxidation resistance is not impaired, however, as the braze itself is stable.

Note the nice filleting of the massive braze metal. Even though the marcel is roughly 0.005 in. away from the base-metal surface, bridging is complete and so insures efficient heat transfer.









CONTROLS. Here we have a compact yet intricate assembly of high-temperature-brazed components that must operate in a control unit employing 900 F bleed gas. Ten braze joints are required on this specific application. High-quality type 347 precision investment castings constitute the basic housing structure. Needle valve seat, bosses, cover plate, and tubulation are brazed during one or more brazing cycles. Brazed subassemblies are employed, being themselves joined into the whole unit in a final brazing operation.

AFTERBURNER SHROUD. The all-metal honeycomb sandwich shroud sections displayed above serve as self-supporting air ducts and also provide a significant thermal barrier. Additional effectiveness of such a shroud may be obtained through use of a heat-reflective coating of silver applied to the inner-diameter shroud surface. A new ceramic process for silver plating has been perfected specifically for this purpose.

The honeycomb sandwich shroud structure illustrated consists of paper-thin type 321 foils, 0.002-in. thick, high-temperature braze bonded to ⅜-in. cell size type 321 core, 3/16-in. in height. Core foil gage is also 0.002 in. The part being held up weighs but 6 lb.

All honeycomb sandwich applications are characterized by extreme braze fillet lengths. The shroud sections shown contain approximately 0.42 miles of braze fillet.

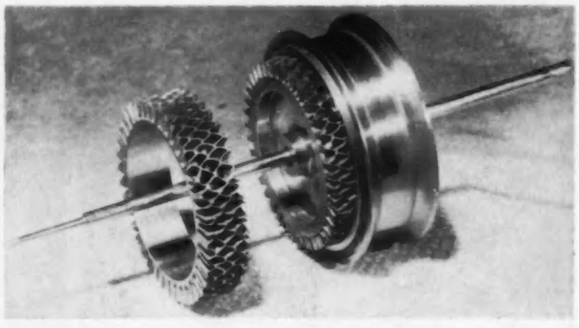
Light-weight type 321 honeycomb shrouds operate up to roughly 1300 F. High-temperature brazed Inconel shrouds maintain integrity at 1700 F. Short-time operation up to 2000 F is feasible.

PISTON ELEMENT. The use of high-temperature pneumatic actuators powered by air or combustion gas bleed offer great promise.

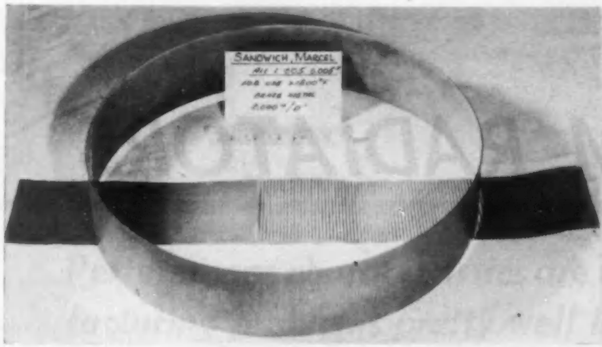
Basic to this problem is the need for low-leakage, low-friction sliding seal elements, such as the design shown at the right.

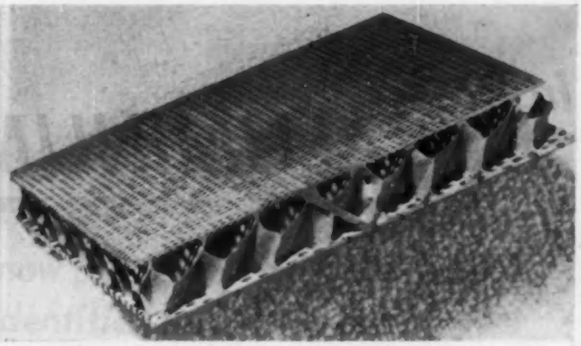
One-eighth-inch cell, 0.004-in. Inconel core has been brazed to a backing ring, which in turn was shrunk onto a piston and rod assembly. Lapping of the open-face structure within a cylindrical bore readily provides a close-fitting combination.

Other designs involve split-piston-ring types and use of slant core to maintain spring contact continuously with the cylinder walls. Slide valves are also under consideration.



Unique advantages of the open-face honeycomb approach are large overall support with minimum contacting area, low galling tendency through use of ceramic coatings, relative immunity to jamming from grit or foreign matter in the gas, and low leakage rate due to labyrinth-type design.





AFTERBURNER LINER. Afterburner liners also help to reduce the afterburner heat containment problem. Above (left) is such a liner, made of Super alloy L-605 (Haynes Alloy 25), which has been fabricated into an aircooled marcel or corrugated-type sandwich. The core consists of 0.005-in. foil in 1/8-in. corrugations. Facings are likewise of 0.005-in. L-605. After brazing at 2100 F, a core pattern may be observed on the facings. This is due to outer facing contact pressure and also metallurgical diffusion of the braze alloy.

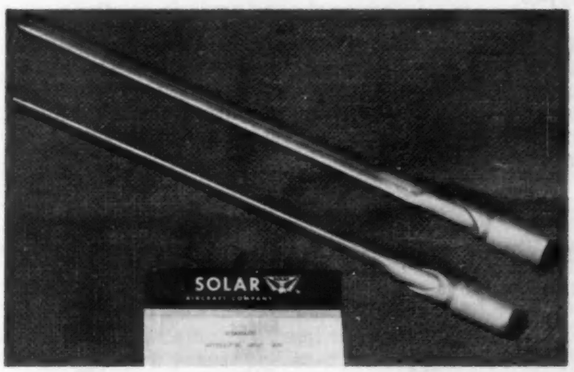
Massive high-temperature brazed L-605 assemblies are feasible for service temperatures up to at least 2200 F. Foil gage honeycomb or marcel-type structural sandwich should find use in the 1500–1900 F range, however, thermal aging effects must be considered.

At the right is shown an experimental honeycomb sandwich structure based on a novel core geometry. The core is a conventional 0.002-in., 1/4-in. cell except that it is disposed at an angle of 45 deg to the faces. In this application, faces are of perforated stainless-steel sheet. By special techniques, high-temperature-braze joining of faces and core can be accomplished without plugging of facing pores with excess braze metal.

By orienting the honeycomb core in proper relation to high-velocity gas flow parallel to one face, a strong self-aspirating effect is produced.

One application for such a slant-core honeycomb sandwich is an afterburner liner. Cooling air would be induced through the permeable facings and into the hot blast stream.

Other areas of interest involve boundary-layer control, sweat-type cooling, and fuel combustion-chamber structure.



AFTERBURNER SPRAY BARS. High-temperature brazing has been successfully applied to fabricated fuel spray bars or nozzles. The 12-in. assemblies shown above consist of flattened N-155 tubes brazed to heavy type 321 base sleeves. A scarf joint design is used to avoid concentration of stress and premature fatigue failure.

IN BRIEF, high-temperature brazing technology is expanding rapidly. The examples given here have shown only a small segment of the present-day art. High-speed flight at high altitudes demands light-weight engines, with the capability of operating at high inlet temperatures. Limitations of present metallurgical technology indicate that turbine cooling or high melting materials, such as molybdenum, will be used.

Use of molybdenum is now limited because of poor oxidation resistance. Metallic coatings and cladding hold promise. Braze joining of clad materials is a logical answer to the assembly problem.

Cooled buckets permit design to higher stress levels and use of sheet-metal components. High-temperature brazing is the favored method of joining.

Heat transfer is the crux of high-speed flight. In all cases of heat transfer where light weight is a critical factor, use of the braze-joining process appears imminent.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price 35¢ to members; 60¢ to nonmembers.)

In Re:

ALUMINUM RADIATORS

THE all-aluminum radiator is just around the next corner . . . or around the corner after that. And the aluminum-fin-with-brass-core radiator has just about arrived.

Successful designs of both types have turned in some service tests which compare satisfactorily with standard copper-using units. . . . But manufacturing problems, including equipment changeover, are still sufficiently unresolved to put commercial mass production probabilities in the future. Particularly is this true of the all-aluminum types.

Necessary maintenance education for dealers and repairmen is another retarding factor to immediate general use of any type of aluminum radiator. Repairs can be satisfactorily made, it is agreed. But methods successful with conventional materials cannot be applied without modification. The fact that aluminum melts at about 1200 F as against copper's higher 2000 F, for example, got some experimental repairmen into trouble while fixing leaks. They were using a solder which melts at about 500 F. When they left their torches in one spot too long, the aluminum fins disintegrated. They found also, that tin-lead solders do not flow as well on the tin-zinc surfaces with which they were dealing as on tin-lead.

Then, too, some leak-repair procedures, found successful, call for skilled operators. "Radiator leaks can be repaired, one manufacturer reports, "by a skilled operator using a small torch and brazing wire, or by the use of plastics."

The all-important question of maufacturing cost seems likely to be resolved on a gradual, rather than any immediately absolute, basis—as is the case with most new items. Costs of the aluminum-brass or composite designs, for example, are likely to be less than the all-aluminum designs in any early mass production adoptions. This is because the aluminum-brass constructions permit use of much existing production equipment. And this could be the determining factor in giving the first mass-production nods to composite designs.

But nobody is yet quite sure of the ultimate cost-performance ratios, even for the aluminum-brass types.

McCord Corp.'s William S. Gale, for example, said recently: "In 1955, we began installation of a pilot production line to supply our customers with limited quantities of composite radiators. Our objective was to learn whether the radiators could be made in mass production at a cost competitive with conventional radiators.

Table 1—Characteristics of Solders for Brass-Tube, Aluminum-Fin Assemblies

	Zn	95% Zn 5% Al Solder	90% Zn 10% Cd Solder	70% Zn 30% Sn Solder	70% Pb 30% Sn[a] Solder
Density, lb per cu in.	0.258	0.239	0.262	0.260	0.351
Liquidus Temperature, F	790	720	750	710	500
Coating Evaluation	Fair	Fair	Good	Good	Excellent
Contamination of Solder by Brass	Moderate	Moderate	Slight	Slight	Little
Strength of Soldered Joints	Strong	Strong	Strong	Strong	Weak
Relative Corrosion Evaluation[b]					
Brass-Al Cores	A	A	C	C	D
Brass-Cu Cores	A	A	B	B	A
Material Cost Factor, % of 70Pb-30Sn[c]	29	27	58	72	100

[a] This solder combination is commonly used for copper-brass radiator construction and is shown in this table for comparative purposes only.
[b] A is highest rating.
[c] For equivalent coating thickness.

Performance characteristics are now pretty well known . . . manufacturing problems pretty well identified. Cost—performance relationships for mass production should soon be available.

"Frankly, we don't yet know whether this is possible. But we do know that in order for the soldered aluminum, brass-tube construction to replace conventional radiators it will have to be equivalent in performance and cost less.

"If the costs of using aluminum and copper are the same or nearly so, copper would still be preferred as the better material in almost every important respect except that of weight."

To some companies already equipped to produce conventional radiators, the composite soldered construction may have current appeal because:

- They can forget about internal corrosion, since all parts in contact with liquid coolants are brass.
- By replacing copper fins with aluminum, about half the weight of the brass-mill products in the radiator is saved.
- Soldering—the traditional method of joining in their industry—would not require wholesale replacement of production equipment.

Soldering, Key to Progress

The currently advanced state of aluminum fin-brass core design rests importantly on the development of soldering fluxes satisfactory for joining the fins and tubes. Great progress has been made along these lines in recent years. Hundreds of possible flux combinations have been tried.

Listed in Table 1 are some solders which have been found satisfactory from the experimental work of the last few years; together with some comments on their application. Some of these resulted from studies originally aimed at developing a noncorrosive soldering flux required to replace the zinc chloride used in manufacturing conventional radiators.

The zinc-tin and zinc-cadmium solders having more than 70% zinc seem to be the most satisfactory for manufacturing aluminum-brass radiator designs.

Some of the fluxes are organic solutions that are non-corrosive; some, inorganic salt mixtures which are corrosive. Residues of the salt fluxes must be removed subsequent to soldering to prevent acceleration of corrosion of the soldered joints.

Procedures for furnace-soldering aluminum-brass radiator cores are essentially the same as for furnace-soldering copper-brass cores. With the aluminum fin construction, however, the times and temperatures for coating the brass tubes and for soldering the cores must be controlled more closely. Otherwise there may be excessive penetration and diffusion of the solder into the brass tubes.

Depending on the solder composition and mass of the assembly, baking cycles in one plant making aluminum-fin, brass-tube cores vary from about one to four minutes at 700 to 800 F. In this case, fumes were found to be a real problem because of the flux used and the ovens which had been satisfactory for conventional radiators had to be redesigned to handle the composite design.

Fin-and-Tube Type Best for Aluminum

It is pretty generally agreed that the fin-and-tube radiator is best adapted to either the aluminum-brass or the all-aluminum unit. Some reason

THIS ARTICLE highspots the progress of the last few years. It is based on three papers:

"The Soldered Aluminum-Fin, Brass-Tube Radiator"

by William S. Gale
McCord Corp.

"All - Aluminum, Brazed, Heat - Transfer Equipment"

by W. O. Emmons
General Motors Corp.

"Aluminum for Tomorrow's Radiators"

by J. D. Dowd, D. C. Vandenburgh
Alcoa Research Laboratories
E. P. White
Aluminum Co. of America

that this type delivers a maximum heat transfer per pound of metal and per unit of frontal area, and can also withstand the high internal pressures demanded in modern cars. Others say it's easier to make.

The disadvantages of the continuous-fin type of radiator, on the other hand, are thought to be only aggravated in the composite aluminum construction.

Manufacturing Problems

It is generally agreed that careful control of manufacturing operations will be essential to mass production of high-quality aluminum-fin, brass-core radiators.

Solder bonds of adequate size must be created . . . and the joints between the fins and tubes must be of excellent quality. There may be as many as 30,000 of these joints in the average radiator core . . . and unless there is excellent bond between fins and tubes, the heat transfer is markedly impaired. (A loss of 10 to 25% is said to be not unusual with poor fin-to-tube contact.)

This problem is emphasized by the wide variations in the performance of joints which have been observed even with the same solder. These variations are believed to be dependent on factors like thickness of solder coating of the brass units; the joining temperatures; the flux composition; and the completeness of flux removal.

Then there is the problem of making tubes. On the conventional radiators, tubes are formed by rolling brass strips into a tube of narrow, elliptical cross-section. A double-locked seam is formed on the narrow edge and the uncoated tube passes through a station where molten tin-lead solder is applied. This coating is then wiped smooth and cooled.

Wiping techniques have turned out to be critical, too, in composite radiator production. A smooth but somewhat thickened coating of the tin-zinc solder is needed. One maker, concerned about the effects of zinc penetration, is using 85/15 brass, 0.006 in. thick for the tubes.

This same producer adopted as a core-baking flux an aqueous solution of hydrazine compounds and their organic derivatives, particularly the 5-membered heterocyclic metallic complexes. Used in a solution of about 20% concentration, this performed well and left very little residue. Other satisfactory and available fluxes contain zinc halides, ammonium halides and possibly stannous halides, as well as exalters such as sodium fluoride. (Experiments with flux solutions containing substantial amounts of alcohol brought an explosion which nearly wiped out the whole research engineering staff.)

Expansion of the aluminum assembly within the clamping frame during baking had a tendency to crush the assembly, which would then shrink on cooling. As a result, the outside spacers sometimes were loosened.

Aluminum as a Radiator Material

Aluminum fins are being made of 1100 and 3003 aluminum, and some experimenters strongly recommend use of an alclad coating. Others say that units tested with such a coating are not convincingly superior to those with the two alloys mentioned. One maker in the latter group finds that 6 to 7 lb of aluminum does the work of 9 to 10 lb of copper in his fin application, even though the aluminum is nearly 0.007 in. thick, as opposed to 0.003 in. for conventional copper fins.

Aluminum radiator tubes can be expected to have a high resistance to a wide variety of coolants, according to Aluminum Co. researchers. While their extensive laboratory tests demonstrate a definite advantage for an alclad coating on brazed aluminum radiator tubes, limited service tests indicate satisfactory performance even from unclad tubes.

The alclad product used in these tests was a composite sheet having a 3003-alloy core with an aluminum-silicon brazing alloy on one surface and a cladding of an aluminum-zinc alloy on the other surface. The aluminum-zinc cladding is anodic to the 3003 core and was placed on the water side to obtain electrochemical protection.

Other conclusions from these Aluminum Co. investigations indicate that:

- Aluminum should be used for all components, such as drain valves. If not, other materials selected should be compatible with aluminum.
- The brazed aluminum radiator will not lose cooling capacity because of loss of contact between fins and tubes . . . because the aluminum-silicon alloy joints have a high resistance to corrosion in a wide variety of environments.
- For the most part, exterior brazed surfaces of tubes in all-aluminum radiators have offered satisfactory resistance to corrosion.
- Susceptibility of outside brazed surfaces to localized attack can be minimized by electrochemical protection by anodic fins . . . and by selected organic coatings.

Field Service Tests

Field service tests of all-aluminum radiators have been widespread and extensive in recent years. In one such test, reported by GMC's Harrison Radiator Division, 29 brazed aluminum radiators were installed on salesmen's cars. The cars were located in all parts of the United States. They were operated in all kinds of weather and on all kinds of roads. None of the installed radiators were treated or painted, as the aim was an accelerated test to reveal weaknesses.

Of the 29 radiators installed:

3 are still in service, having accumulated from 44,000 to 76,000 miles in about 58 months.
3 were removed because of accident damage.
11 were removed when the car was sold.
2 were removed when the anchorage cracked.
3 were removed because of tube leaks.
5 were removed because a poor weld resulted in tank-to-header leaks.
2 were removed because of an outlet leak.

Contrary to expectations, tube leaks developed from the outside in; not from the inside out. Aluminum corrosion of the pit type was found.

These three papers are available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ each paper to members; 60¢ each paper to nonmembers.

2-Stroke-Diesel Locomotives Are Successfully Turbocharged

Ross C. Hill, Union Pacific Railroad Co., and
Werner T. von der Nuell, AiResearch Industrial Division, Garrett Corp.

Based on paper "Railroad Experience with a Turbocharged 2-Cycle Diesel Engine," by Hill, and "Notes on Turbocharged 2-Stroke-Cycle Diesel Engines," by von der Nuell.

APPLICATION of AiResearch T-30 turbochargers to Union Pacific's 2-stroke-diesel locomotives running from Omaha, Neb., to the Pacific Coast has resulted in a definite improvement in altitude performance. The installation has been accomplished without major changes to either engine or locomotive, and with the introduction of but few additional problems.

Performance

For comparable conditions of loading and fuel flow, the turbocharged engine at sea level delivers about 4% more power than the standard engine and about 5½% more at 4000-ft altitude.

Extensive tests show that before serious attempts are made to increase the engine rating more than 10%, the compression ratio must be reduced from the nominal standard 16/1.

Fig. 1 shows results with hastily constructed experimental manifolding. These show a moderate but definite improvement throughout the range of engine loads.

Turbocharger and Installation

The T-30 turbocharger used on these locomotive engines is shown in Fig. 2. It consists of a centrifugal compressor and a centripetal turbine, uses engine oil for lubrication, and requires no water cooling. There is one turbocharger for each four cylinders, or four units per engine.

By removing the exhaust collectors of the standard EMD 16-567C engine, the space required for the turbochargers was made readily available. The turbocharger installation on top of the engine (as compared to the four collectors of the standard en-

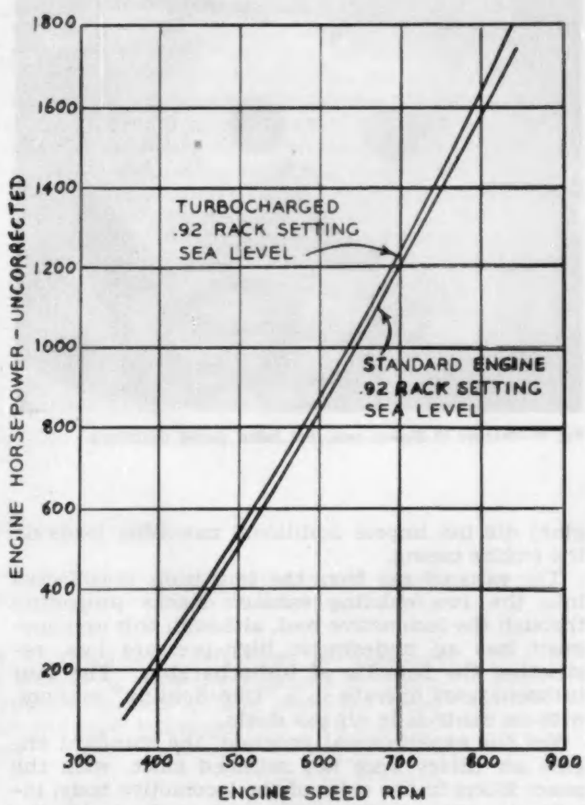


Fig. 1—Power output of turbocharged engine compared with that of standard engine.

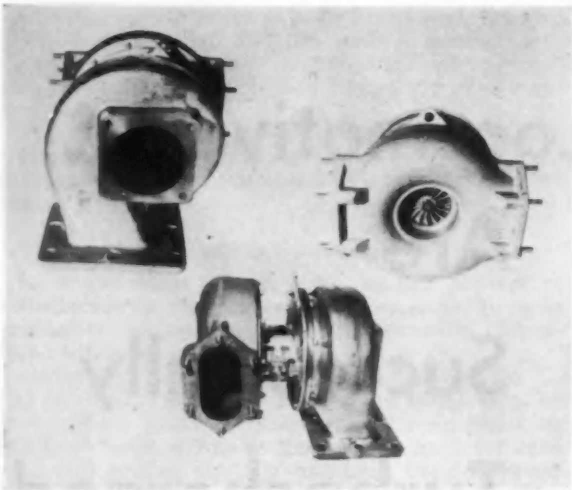


Fig. 2—AiResearch T-30 turbocharger consists of centrifugal compressor and centripetal turbine.

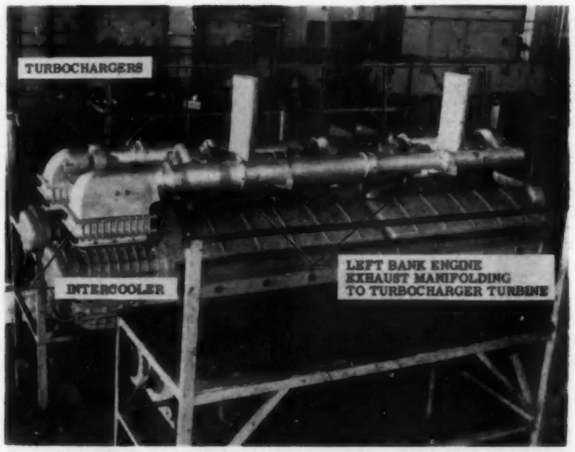


Fig. 3—Four AiResearch turbochargers and intercoolers were installed on EMD 16-567C diesel engine for Union Pacific locomotive.

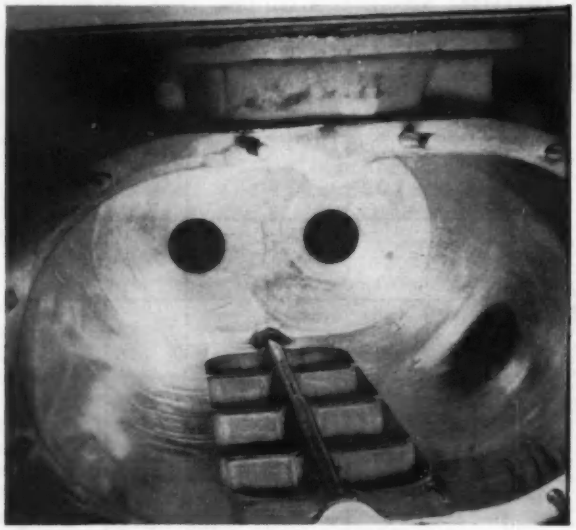


Fig. 4—Interior of blower case that failed during operations.

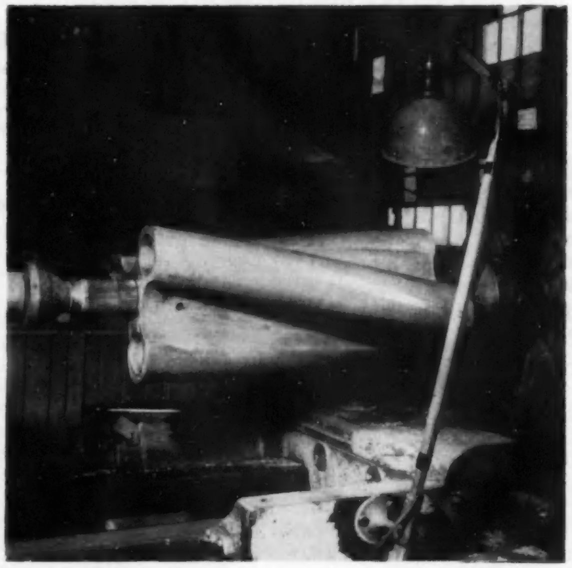


Fig. 5—Failed blower rotor.

gine) did not impose additional mounting loads on the engine casing.

The exhaust gas from the four units is collected into the two existing exhaust stacks projecting through the locomotive roof, although this arrangement has an undesirable high-pressure loss, restricting the benefits of turbocharging. The four turbochargers operate in a "free-floating" manner, with no controls in air gas ducts.

For the experimental program, the standard engine air filters were not retained since, with the panel filters in the sides of the locomotive body, intake air contamination was not feared. Inside the locomotive body, air entered the turbochargers through calibrated bell-mouth-shaped inlet ducts. On the discharge side, the compressed air was collected in two parallel manifolds running along the top of the engine.

Naturally, the Roots blowers remained on the engines and, in order to keep air temperature to the engine as low as possible, charge-air intercoolers were attached to the inlet flange of the blowers (Fig. 3). These heat exchangers were also experimental, being built of aluminum with finned-plate core, using engine cooling water as the heat sink, with this heat rejection amounting to a maximum of only 6% of the engine heat rejection. The maximum pressure drop on the charge-air side of the

heat exchanger was 0.5 in. of Hg; 2-psi pressure drop was observed on the water side.

Operating Problems

After standing tests at various altitudes up to 4,000-ft, the test locomotive was placed in helper service out of San Bernardino, Calif.

During the entire time of testing and rail operation, no mechanical or function trouble occurred in the turbocharger units themselves. After close to 2000 hr total running time, they were fully disassembled and thoroughly inspected dimensionally. Everything was found to be in excellent condition, with no indication of distress or wear. There were a few small knicks on two turbine blades, resulting from engine piece going through. In radial turbine wheels, such damages, sometimes not just small in size, cause little, if any, concern. They are usually not even discovered in operation, and are just smoothed out at overhaul periods. The trouble-free operation of the turbochargers could be expected because, in this application, the operational speed of the turbochargers always stayed below 75% of rated speed for continuous duty, and the temperature of the exhaust gas never got closer than within about 300 deg of rated maximum for these turbochargers.

After about five trips in service, however, the Roots blowers failed. Inspection showed that the aluminum rotors rubbed on the case at the inlet, due to differential expansion. Rotor length expansion also caused rubbing at the end opposite the thrust bearings. As an expedient, the rubbing was eliminated by turning down the rotor diameter and shimming the thrust bearing end of the rotors. Blower clearances on the standard engine are very sensitive and have been increased between the B and C model engines. Fig. 4 shows the interior of a failed blower case and Fig. 5 shows one of the rotors that failed.

While the locomotive was out of service to cure the blower problem, the two oil control rings on the piston skirts were replaced by standard compression rings and the oil drain holes plugged. This reduced air leakage to the crankcase slightly but was disappointing because of excessive lube oil consumption. The unit was again assigned to helper service and performed very creditably except for the excessive oil use.

It was then learned from the builder that a large part of the air leakage could be traced to the blower shaft seals. These were reversed and the crankcase pressure dropped to a respectable figure. Development of a double-lip seal is under way.

At the same time a new type of oil control ring was tried. This ring in the top oil ring groove of the skirt had a triangular section and was forced against the cylinder by a helical spring expander. The new ring was too severe and resulted in scoring after 5 hr of load test. Since then a standard compression ring in place of the top oil control ring with ring groove drain holes plugged has proved satisfactory.

Throughout the experimental period the exhaust stacks were troublesome because of cracking and expansion joint leakage.

A new set of manifolding for application to three units is under construction. This will be a constant-pressure system with a single tubular exhaust collector feeding all four turbochargers. Energy recovery in exhaust stacks will be improved and the system will be cleaned up generally for better flow. Initially, one unit will be equipped to take engine air from outside the hood. This should show some gain over standard units, which force the engine to breathe a restricted flow of preheated air.

During the test runs it was observed that noise level was noticeably less both in the cab and outside the locomotive. Engine men were favorably impressed with this result and were surprised that no "turbo whine" was heard. At the normal injector rack settings there was noticeably less exhaust smoke. This was especially remarkable during engine acceleration, when the four small turbochargers responded more rapidly than the standard engine and much more rapidly than engines equipped with large single turbochargers.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Our Business Aircraft Fleet

■ *Today, the business aircraft fleet numbers 23,000, a civil air armada many times larger than all combined domestic airlines—which maintain an active fleet of approximately 1250 airplanes.*

To illustrate its mobility, businessmen representing every type of business last year flew an estimated 4,300,000 hr as compared with the 3,200,000 hr flown by the nation's airlines. These 23,000 airplanes arrived at and departed from more than 7000 U.S. airports of every size and type, in comparison with approximately 550 cities served by the airline fleet.

—Dwane L. Wallace

Aircraft need for greater brake capacity in smaller envelope leads to . . .

Cerametallic

THE advent of the jet airplane with its high landing speeds and the demand to cut down wheel and brake space, long ago made apparent that organic friction materials would not suffice.

Some idea of the magnitude of the problem is illustrated by Fig. 1. In 1936, we were hard pressed to design a brake energy capacity of 1500 ft-lb/sq in. of wheel, brake, and tire envelope area. By 1950 the figure had risen to 10,000 and since then has jumped to 50,000 in some current designs. These increases have been realized by improving wheel, brake, and tire design; using space more efficiently, and employing better materials, among them cerametallic linings.

In 1945, we asked manufacturers of friction materials for aircraft brakes to develop a material replacing organic resins and binders with inorganic materials which would not deteriorate at temperatures under 2000 F. Laboratory tests with organic materials had proved to us that lining wear was not a linear function of work done, as widely believed, but a function of flash and soaking temperatures resulting from work done. Slightly less than 20% of wear resulted from work done, 40% came from flash surface temperatures, and the remaining 40% from the soaking temperatures after the brake stop had been completed. From this it was concluded that a material which could operate continuously at temperatures in excess of flash and soaking temperatures without deterioration would mean longer material life.

The makers of friction materials thought the use of inorganic or ceramic material unsound. They had tried additions of such elements with unsatisfactory results. The materials were basically brittle and low in strength, and usually galled or scored the opposing surface. Convinced that our idea might still have possibilities, we undertook an exploratory program.

Small annular test buttons were made from such materials as plaster of paris, transite, fire clays, fire clay cement, silica sand, and cinders. The brittleness and low strength of which we had been warned proved true. Generally speaking, all such materials had a low thermal shock resistance. We learned that we could not rely on ceramics to withstand the imposed mechanical stresses; some sort of metal container had to carry the torque loads. Even this did not relieve cracking due to thermal shock and a metallic matrix had to be added to strengthen the body of the friction material.

The original research program and later extensions of it leading to development of Cerametalix lining, has been based on the following theories:

- Ceramic bodies are inherently weak and brittle and must embody some mechanical means to attain required strength.
- A metallic matrix is required to support the ceramic bodies and to conduct heat away from the rubbing surfaces.
- The ceramic bodies would be used for the friction element as well as for partially insulating the metallic particles to protect them under very high surface temperatures.
- The physical combination of metals and ceramic was needed for ideal wearing surface.

We believe the real secret in producing a cerametallic friction material lies in forming a proper spinel on the surface. Ingredients and techniques used to form this hard spinel surface and to maintain it in a thin layer largely govern the production of a usable material.

A good friction material should have, in our opinion, the following nine properties:

1. Adequate mechanical strength through all operating temperatures.
2. Temperature and thermal shock resistance.
3. High heat absorbing capacity, that is, high specific gravity, specific heat, and thermal conductivity.
4. High and consistent coefficient of friction.
5. Low wear rate.
6. Smooth engaging characteristics.
7. Compatibility with mating surface (minimum galling, wear, or heat checking).
8. Non-fusibility with opposing surface.
9. Non-combustibility.

Cerametalix lining minimizes the strength prob-

W. H. DuBois, Bendix Products Division, Bendix Aviation Corp.

Based on paper "Cerametallic Friction Material."

Friction Material

lem by design (Fig. 2) and by use of metallic matrix materials. The restraining member minimizes the strength necessary in the friction material and allows use of materials such as ceramic friction producing additives which normally weaken the material and cause brittle failure. Since the metallic matrix forms around the ceramic grains and retains them in a friction producing position, its strength is not permanently destroyed by high temperature, and it cooperates with the ceramic so that high temperature strength properties of the composition are superior to the metal alone.

Metal-ceramic friction materials in general tend to have a decreasing coefficient of friction with repeated applications, due to formation of a glaze on the surface. This glaze affects all of the friction properties, but it is particularly desirable in reducing wear of the friction article. Control of the glaze composition of properties has been a major factor in Cerametalix development. Compositions have been developed which will promote glaze formation and control its effects on friction properties for most of the conditions encountered in clutches and brakes. The wear rate is also controlled to a large extent by the amount of ceramic material incorporated in the lining.

One of the most essential properties of a high temperature friction material is the absence of welding or fusing to the opposing surface, regardless of overload or abuse. High ceramic content and good heat resisting properties impart this property to Cerametalix.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

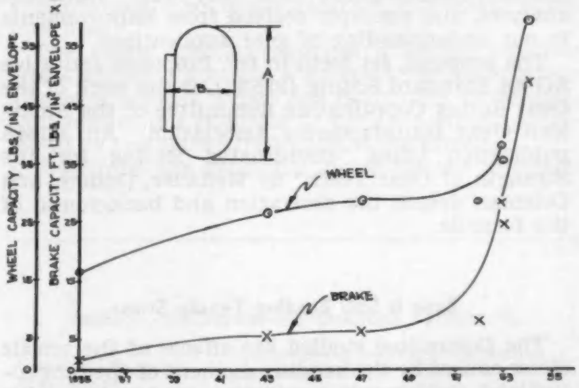


Fig. 1—This illustrates the demand for ever greater wheel and brake capacities in smaller envelopes which spurred the development of Cerametalix friction material. The line diagram represents the cross sectional area of a wheel, brake and tire.

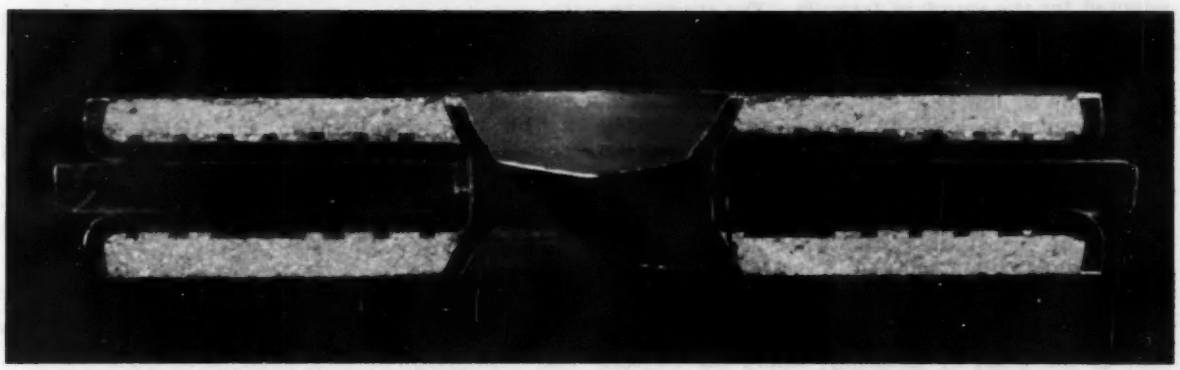


Fig. 2—Design and the use of metallic matrix materials minimize the strength problem in Cerametalix linings.

AGMA Proposes New Formula

A proposed formula for calculating strength of gear teeth introduces seven new factors into the long-used Lewis formula. The factors account for knowledge developed since the formula was originated.

The new formula can be applied to spur, helical, herringbone, straight bevel, spiral bevel, or hypoid gears. It can easily be modified to incorporate more precise computations, new test data, advanced analyses, and concepts derived from improvements in our understanding of gear applications.

The proposal, set forth in the Proposed Tentative AGMA Standard Rating (225.01), is the work of the Gear Rating Coordinating Committee of the American Gear Manufacturers Association. An AGMA publication titled "Coordinated Rating for the Strength of Gear Teeth" by Wellauer, Dudley, and Coleman details the derivation and background of the formula.

Basis is Still Bending Tensile Stress

The Committee studied the effects of the tensile stress caused by the bending moment of the tangential load, the compressive stress caused by the radial load component, and the combined stress formed by the shear and the tensile stresses. These studies indicated that, as Lewis had theorized, bending tensile stress is the maximum for almost all practical combinations of gear teeth. Therefore, it was adopted for the standard formula. The studies indicated also that maximum loading applied low on the tooth profile in conjunction with high pressure angles needs special design analysis and consideration of the combined shear tensile stresses.

The Committee retained the Lewis assumption which is still apparently the best available for the computation—that the tooth-shaped beam can be simulated by a parabola tangent to the tooth profile at the most highly stressed section. A parabola is a beam of "constant stress" when loaded with a tangential force applied at the vertex. Such a parabola has the same stress in the outer fibers at all the transverse sections. Actually, the gear-tooth shaped beam is stressed less than the parabola except at the point of tangency, where the stresses are theoretically identical.

For the tangential component of load applied at the vertex, Lewis arrived at the formula:

$$W = SFpy \tag{1}$$

Where, S = *bending stress*
F = *face width*
p = *circular pitch*
y = *Lewis factor*

AGMA Proposal

The AGMA derived an equation for bending tensile stress which includes three groups of terms, one concerned with the load, the second with tooth size, and the third with stress distribution:

$$s_t = \frac{W_t K_o}{K_v} \; \frac{P_d}{F} \; \frac{K_s K_m}{J}$$

Where,

Load W_t = transmitted tangential load
K_o = overload factor
K_v = dynamic factor

Tooth Size P_d = diametral pitch
F = net face width

Stress Distribution K_s = size factor
K_m = load distribution
J = geometry factor

The relation of calculated to allowable stress is:

$$s_t \leqq \frac{s_a K_L}{K_T K_R}$$

The resulting equation for allowable tangential load is:

$$W_a = s_a \frac{K_v}{K_o} \; \frac{F}{P_d} \; \frac{J}{K_s K_m} \; \frac{K_L}{K_T K_R}$$

The similarity between the AGMA and Lewis equations allowable load is apparent. The terms S and s_a, F and F, P_d and $1/p$, and Y and J have similar connotations. But seven additional factors, K_o, K_v, K_s, K_m, K_L, K_R, and K_T, appear in the AGMA formula.

The Seven Factors

Here's why AGMA added the seven factors to the Lewis formula:

The overload factor, K_o, accounts for the magni-

for Gear Tooth Strength

E. J. Wellauer, Assistant Chief Engineer, The Falk Corp.

Based on paper "What Do Calculated Gear Stresses Mean?"

tude and partially the frequency of application of the overload typical for particular applications of driver-driven machine combinations. Where possible, it should be established on the basis of field experience. Table 1 gives typical values for the overload factor, derived from the 20 years of field experience behind the AGMA durability ratings for gears. In the absence of field experience with an application, factors chosen from the table or from actual horsepower or torquemeter readings can be a guide to selection of overload factor.

The dynamic factor, K_v, recognizes that the rotation of the gears imposes an additional load caused by dynamic effects. Its magnitude is influenced by tooth spacing and profile errors, pitch line speed and rpm, inertia of pinion and gear, transmitted load per inch of face, and tooth stiffness.

Dynamic factors typically fall between 0.35 and 1.00. Experimental determination of the factor is a complex process dependent on strain gages and other modern instrumentation.

The size factor, K_s, reflects non-uniformity of material properties. It depends primarily upon pitch of teeth, diameter of parts, ratio of tooth size to diameter of part, face width, area of stress pattern, ratio of case depth to pitch, and hardenability and heat-treatment of materials.

Perhaps the size effect is a reflection of the statistical probabilities of encountering a weak spot.

For high quality materials heat-treated by the best techniques, very little size effect is obtained. That is, the size factor is about 1. However, factors for fine pitch bevel gears may be as high as 2. This undoubtedly reflects the greater strengthening effect that case carburizing has on the finer pitches.

The load distribution factor, K_m, depends on misalignment of axes of rotation, alignment errors due to tooth inaccuracies, and elastic deflection of shafts and bearings under load.

Errors in cutting gear teeth, excessive elastic deflections, or high bearing clearances can be great enough to cause less than the full face width to contact. Or, even where the full face width contacts, there may be non-uniform loading.

It is possible to calculate the load distribution factor, given (1) the amount of face width working under different amounts of misalignment, (2) the misalignment, (3) a stiffness constant, and (4) the transmitted tangential load. The factor tends to lie between 1 and 4.

The geometry factor, J, is similar to the Lewis form factor in that it evaluates tooth shape. It recognizes that the ordinary gear tooth is a stub beam with varying widths. Loadings close to the root of stub beams are not easily analyzed by existing stress formulas.

The Lewis formula assumes a simple bending stress system. Actually a complex combined stress system is present, which has fairly high stress concentrations and responds to dynamic effects as allowed by the elastic flexibility of the system.

Therefore, the geometry factor for the proposed

Table 1—Recommended Overload Factors, K_o

Character Of Power Source	Character Of Load On Driven Machine: Uniform	Moderate Shock	Heavy Shock
Uniform	1.00	1.25	1.75
Light Shock	1.25	1.50	2.00
Heavy Shock	1.50	1.75	2.25

Table 2—Life Factors, K_L

Number Of Cycles	Spur And Helical Gears: 300 Bhn	Spur And Helical Gears: Case Carburized	Bevel Gears Case Carburized
1,000	3.2–3.6	2.6	4.6
10,000	2.5–2.4	2.0	3.1
100,000	1.8–1.6	1.5	2.1
1 million	1.4–1.1	1.1	1.4
10 million	1.0–1.0	1.0	1.0
100 million	0.8–0.8	0.8	1.0

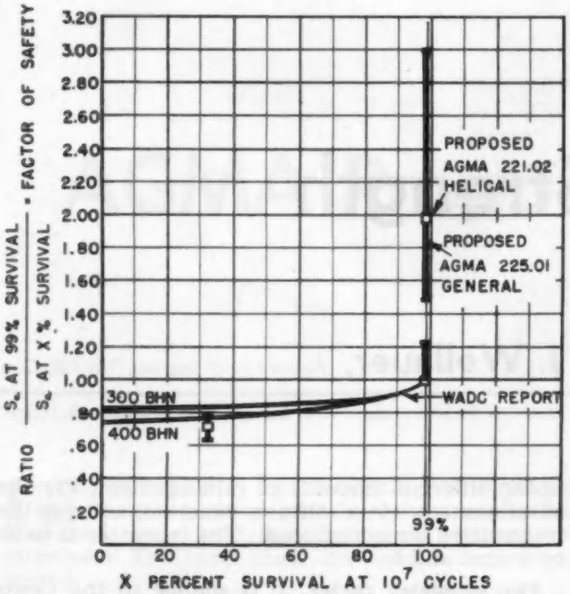


Fig. 1—Factor of safety versus proportion expected to survive 10,000,000 cycles. This factor gives the designer a chance to design for maximum safety or—when required by economic or technical reasons—to design for a calculated risk.

AGMA practice evaluates the shape of the tooth, the position at which the most damaging load is applied, stress concentration effects, and the sharing of load between one or more pairs of teeth.

The life factor, K_L, adjusts the allowable stress for the required number of cycles. Typical values appear in Table 2. Data on which life factors may be based have been published.

The factor of safety, K_R, is introduced in the AGMA strength equation to give the engineer an opportunity to design for maximum safety or—when required by economic or technical reasons—to design for a calculated risk. It is employed not to cover ignorance but to accommodate modern notions regarding probable percentages of failures. Fig. 1 shows a proposed general range and specific values for helical gears.

The temperature factor, K_T, allows for the tempering effect on the material and the dimensional distortions which heat may produce. For most spur and helical gears, if the maximum oil or gear blank temperatures do not exceed 250 F, the factor is generally taken as 1.0. In some instances when case carburized gears operate above 160 F, a value greater than 1.0 is required. For those cases, the bevel gear formula (temperature factor equals the sum of 460 and the operating temperature of cooling oil in degrees Fahrenheit divided by 620) is a good guide.

Significance

Application of the proposed rating formula shows that major differences in capacity can result from the small differences in accuracy normally encountered in and between production runs.

To the engineer involved in gear testing, this should indicate that considerable scatter can result in test results unless the range of accuracy tolerances is maintained within narrow limits.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

MAKE–or–BUY Questions . . .

. . . sometimes require extensive analysis; sometimes can be resolved by application of standard formulas.

B. R. Zitner, Globe-Union, Inc.

Based on talk made at Cost Reduction Programs panel of an SAE Tractor Production Forum.

ALMOST every make-or-buy question should be decided on the basis of which alternative will yield the greater profit. This basic approach holds whether:

a. A substantial investment is required—and, consequently, a thorough analysis is justified

or

b. The problem involves merely a small part which goes into an assembly.

But the specific steps leading to a final decision should be quite different—because the specific problems are quite different.

Big Investment Questions

When management is asked to invest large sums in buildings, equipment, and tooling, it wants (and needs) to have answers to questions like these:

- What total investment will be required?
- What annual cost savings can be expected?
- On what items will costs be increased?
- What return can be expected on the money invested?

When lending money on a mortgage, in other words, management wants to get its money back,

plus a specified minimum return for the *use* of that money. A greater return can be regarded as so much gravy.

Usable Formulas

The most widely-known approach to the make-or-buy problem developed in recent years is the M.A.P.I. formula, developed by the Machinery and Allied Products Institute. This formula specifically is aimed to evaluate the economics of replacing equipment. But it may be used also to evaluate almost any alternative where an investment is required.

A. O. Smith Corp., which requires a specified minimum return on all new investments, has developed its own formula to produce that result.

A third approach is the "Profitability Index," developed by the Food Machinery and Chemical Co. This procedure analyzes the flow-back of cash after taxes which can be expected from any investment. Then it computes the "Profitability Index" as the yield on an annuity equal to the amount of the investment. This procedure has several specific advantages:

1. It is applicable to all types of investment, provides a basis for comparison;
2. It takes into account the effect of depreciation and income tax on profits. (Depreciation has no direct bearing on return on investment other than its effects upon income taxes.);
3. It takes into account the TIMING of capital investments, expenses, and savings to the company.

None of these plans, however, eliminates the need for good judgment. Neither do they eliminate the risk of obsolescence, nor of later availability of new or better methods.

How to Make Routine Decisions

To make the smaller, routine decisions, at least four factors should normally be considered. At one ceramics plant, for instance, where price alone does not determine the make-or-buy decisions, the following steps are taken:

COST: Quotations from venders are obtained on parts which may be purchased. These are compared to the company's own costs. . . . This checkup is done *periodically* on parts which, the company knows from experience, it usually can make cheaper than it can buy. But quotes are always obtained from places where, from past experience, the company knows it can usually buy cheaper than it can make.

CAPACITY: When manufacturing capacity is scarce within the company—and the volume does not appear sufficient to justify purchasing additional equipment, this company buys. (For example: It usually buys certain screw machine parts of the type which are less suited to its particular machines. If, however, its own plant capacity is not being used, it will bring those parts back into its own shop to absorb overhead.)

TYPE OF EQUIPMENT: This company will buy when the projected volume isn't large enough to warrant investment in equipment not already in the plant.

PROCESS KNOWLEDGE: This company buys when it lacks the process knowledge necessary to produce the part under study.

Always Visits Vendors

"When we consider buying," one company executive says, "we visit the shops of suppliers who think they can supply the part at less than our cost. We survey their shops, equipment, and tooling. We have to convince ourselves that he can meet our requirements as to quantity and quality. Also that he can produce at the cost quoted.

"If we have serious doubts, following any given survey visit we either take the business elsewhere—or make the part ourselves.

"We also use discretion and care lest outside shops become a source of information for our competitors."

(The report on which this article is based is available in full together with reports of seven other panels of the 1956 SAE Tractor Production Forum. The complete report (SP-316) is available from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3 to nonmembers.)

(Panel members: R. M. Bruesewitz, Power Products Corp., leader; R. A. Dimberg, Allen-Bradley Co., secretary; F. M. Hunt, Evinrude Motors Division of Outboard Marine & Mfg. Co.; Carl Rasmussen, Waukesha Motor Corp.; B. R. Zitner, Globe-Union, Inc.; Roger Hubbel, Allis-Chalmers Mfg. Co.; and N. J. Kimber, Wagner Iron Works.)

Atomic Bottlenecks

■ *Progress in the development of automotive nuclear heat engines depends to a major extent on developing new types of reactor fuels, new types of nuclear reactor containers, new types of coolants and working fluids for heat engines, and new types of materials for biological shields and other components.*

—F. L. Schwartz and H. A. Ohlgren

How to Regulate

Carl C. Saal

Chief, Vehicle Operations Section, Highway Transport Research Branch, Bureau of Public Roads

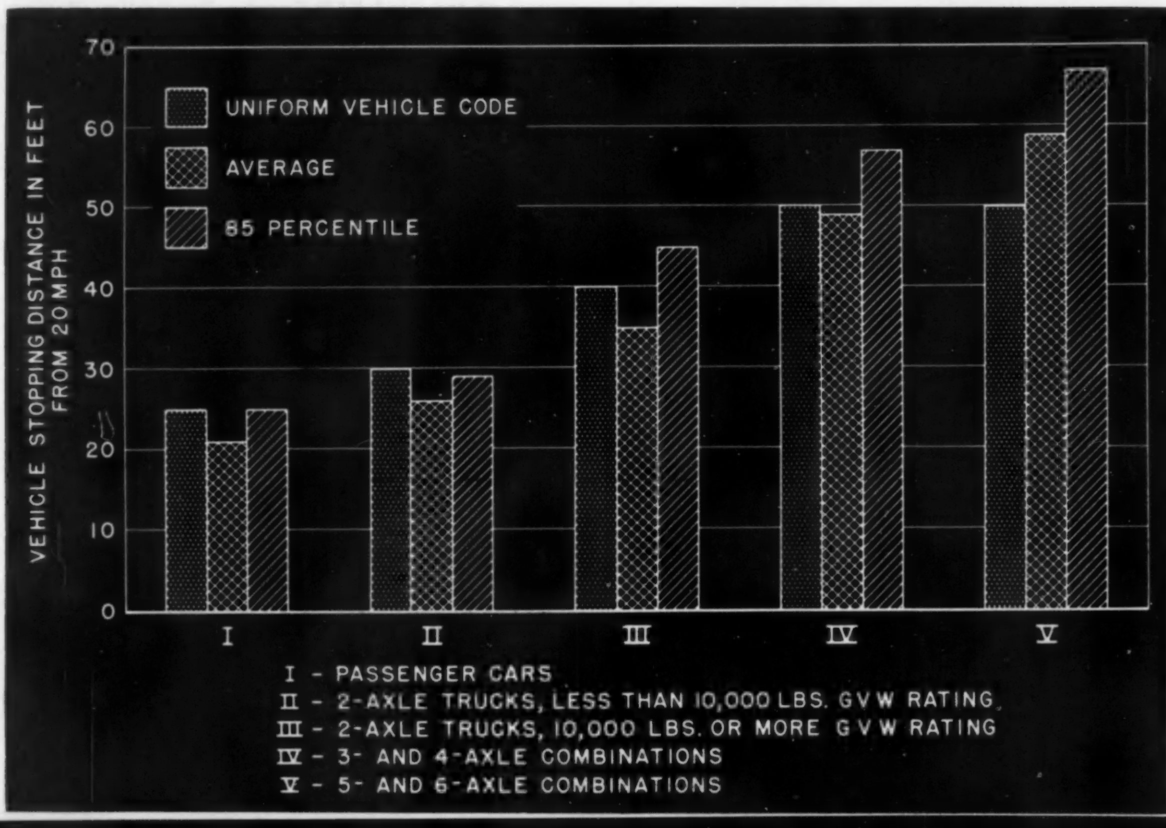
Based on paper "A Practical Stopping Ability Regulation."

Table 1—Uniform Vehicle Code (Sec. 12-302)—Performance Ability of Brakes

	Vehicle Stopping Distance[a], ft	Deceleration, ft per sec per sec	Equivalent Braking Force, % of vehicle or combination weight
Passenger Vehicles, Not Including Buses	25	17	53.0
Single-Unit Vehicles with Manufacturer's Gross Vehicle Weight Rating of Less Than 10,000 Lb	30	14	43.5
Single-Unit, 2-Axle Vehicles with Manufacturer's Gross Vehicle Weight Rating of 10,000 Lb or More	40	14	43.5
All Other Vehicles and Combinations with Manufacturer's Gross Vehicle Weight Rating of 10,000 Lb or More	50	14	43.5

[a] Vehicle stopping distance: The distance traveled between the point at which the driver starts to move the braking controls and the point at which the vehicle comes to rest.

Fig. 1—Uniform Vehicle Code requirement compared with vehicle stopping distances of passenger cars and loaded commercial vehicles operated in everyday traffic.



Vehicle Braking Ability

PRACTICAL procedures for regulating braking ability of all types of motor vehicles might be set up in three steps:

1. Propose a model stopping ability regulation that provides for the maximum safety of operation with avoidance of undue requirements for the operators and manufacturers of motor vehicle equipment.
2. Get the new brake code adopted by the states and to make certain that standard testing requirements are clearly specified.
3. Obtain adoption of an effective enforcement program in each state.

Stopping Ability Regulation

A model stopping ability regulation has now been developed and incorporated in the Uniform Vehicle Code. It is given in Table 1.

The requirements were originally developed by the Bureau of Public Roads after a broad research program on vehicle brakes had been carried out with the help of both government agencies and industry. The report[1] issued by the Bureau was then reviewed by a Brake Subcommittee of the National Committee on Uniform Traffic Laws and Ordinances. This group recommended that the requirements set forth in this report be adopted. The parent committee did so, including them in the consolidated Uniform Vehicle Code.[2]

The basis for the selection of values for vehicle stopping distance is shown in Fig. 1. The selected values are definitely reasonable except possibly for group V vehicles, which appear to be penalized.

These 5- and 6-axle combination units must be well maintained and in some cases major repairs will

[1] "Braking Performance of Motor Vehicles," by C. C. Saal and F. W. Petring. Pub. by U. S. Government Printing Office, Washington 25, D. C. Price: 55¢.

[2] Uniform Vehicle Code. Revised 1954. A consolidation and rearrangement of Acts I–V heretofore published separately. Pub. by National Committee on Uniform Traffic Laws and Ordinances, Washington, D. C.

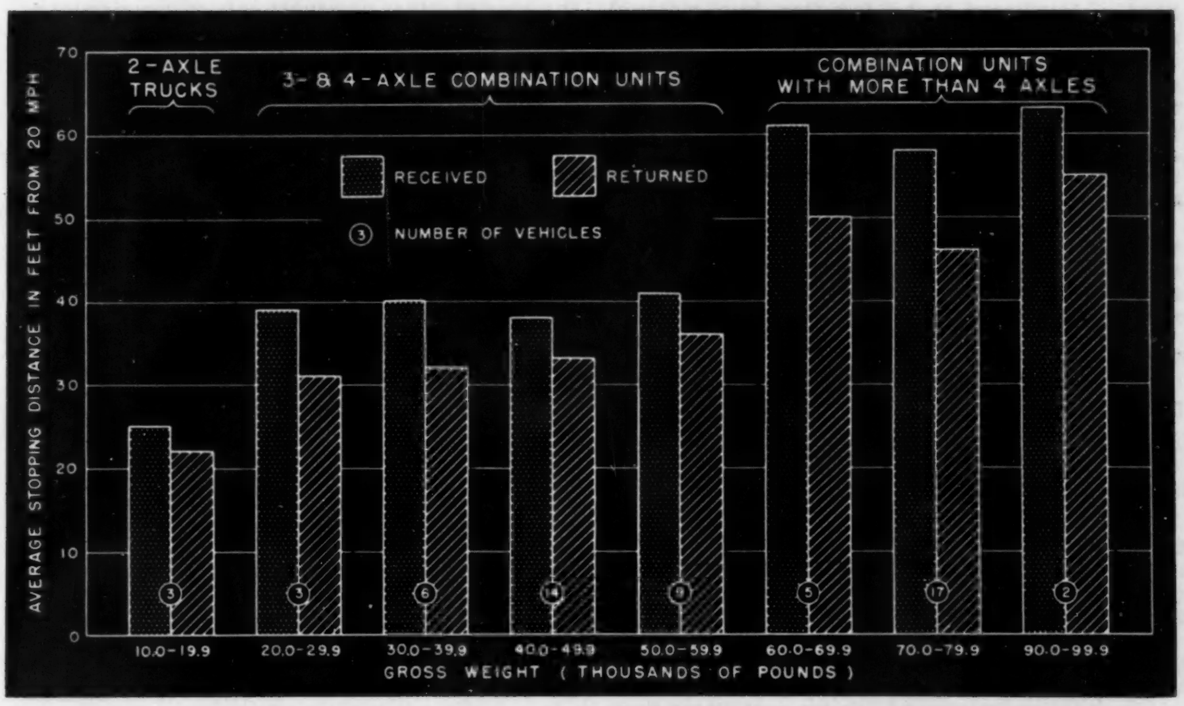


Fig. 2—Variation of average vehicle stopping distances with gross weight for commercial vehicles selected from service.

be necessary, in order for these vehicles to meet the requirement. However, the results contained in Fig. 2 indicate that the 50-ft stop can be met with reasonable maintenance and repair. In order to lower the requirement for this group it would have been necessary to split the combination units into two classes. Otherwise, a requirement (say 60 ft) for all the combination units would have permitted 3- and 4-axle combination units to operate with unsafe brakes.

The requirement for deceleration or equivalent braking force was retained at 14 ft per sec per sec, except for passenger cars. Here, the requirement was raised to 17 ft per sec per sec to be commensurate with the stopping capabilities of passenger cars. The rate of 14 ft per sec per sec is practical in view of the observed performance of commercial vehicles, especially considering the characteristics of the existing brake testers.

Recommended Testing Requirement

The manner in which the performance requirement will be enforced is extremely important if confusion and unfairness are to be avoided. Based on the results and conclusions of the Bureau of Public Roads report and experience gained in the systematic testing of about 7000 vehicles of all types, the following specific testing requirements are recommended:

1. Deceleration shall be measured with an inertia-type portable decelerometer, braking force with a drive-on-and-stop type of tester or brake chassis dynamometer (roller-type tester), and vehicle stopping distance with the gun method or a device that measures within $\pm$...% of the gun method.

2. Road testing shall be conducted on a substantially level (not to exceed $\pm 1\%$ grade), dry smooth, hard-surfaced road, that is free from loose material and that has a coefficient of friction of not less than .... The driver shall stop the vehicle from a speed of approximately 20 mph in the shortest possible distance and in the customary manner, using the service brakes only. A means for accurately measuring vehicle speed to within $\pm$...% shall be used in connection with measuring vehicle stopping distance.

3. Stops in the inspection station shall be made with a test driver from an initial speed that is within the range of ... mph to ... mph, and from the highest possible speed in the case of commercial vehicles with power braking systems.

4. To meet the requirement, a minimum of ... stops and a minimum of ... min between stops shall be permitted.

5. Portable decelerometers shall be located as near the center of gravity of the vehicle as practical.

6. Tests conducted with inertia-type brake testers shall be invalidated if there is a sudden increase in braking force near the end of the stop.

7. Buses while in actual operation in public service, regardless of whether passengers are being carried, shall not be required to submit to brake tests.

8. If practical, public-service and school buses (not in the service of the public) and property-carrying vehicles shall be tested in a loaded condition. Because of the difficulty in obtaining and loading suitable test weights, the testing of buses in a loaded condition must practically be limited to special tests of a very small sample of any fleet. The testing of loaded property-carrying vehicles in inspection stations may also prove impractical except in special cases because of loading difficulties.

9. Property-carrying vehicles loaded in a manner that might result in injury to persons, equipment, or load shall be excused from test until a later date to be designated by the enforcement officer.

Recommended Enforcement Program

A practical approach to the formation of a satisfactory enforcement program is outlined in Table 2. This table has been developed from a consideration of the following points:

1. The operation of inspection stations is the only feasible means for the brake testing of all vehicles licensed in a state or its subdivision. This is true because road testing with either a test wheel or decelerometer requires so much time that only a spot checking of either passenger cars or commercial vehicles is practical.

2. The effectiveness of the brake testers which measure braking force or deceleration in the testing of vehicles other than passenger cars or very light trucks either on the highway or in an inspection station is very questionable. Spot checking of commercial vehicles on the highway for vehicle stopping distance is therefore highly desirable.

3. The brakes of commercial vehicles, because of their greater annual mileage and greater weight in proportion to engine braking, require more frequent attention, another reason for spot checking those vehicles on the highway.

Table 2—Recommended Brake Performance Requirement Enforcement Programs, in Order of Effectiveness

Alternate Programs, in Order of Effectiveness	Methods of Inspection[a]: Passenger Cars and Very Light Trucks		Other Commercial Vehicles[b]	
	Station Inspection	Highway Spot Check	Station Inspection	Highway Spot Check
Alternate A	B or D	D	B or D	S
Alternate B	B or D	——	B or D	S
Alternate C	B or D	D	B or D	D
Alternate D	——	D	——	S
Alternate E	——	D	——	D

[a] B = braking force test; D = deceleration test; S = vehicle stopping distance test.
[b] Except buses in the service of the public.

Man Is Being Adapted To Increasing Temperatures

John R. Poppen, M.D., U. S. Navy (Ret)

Excerpts from paper "Man's Adaptation to Increasing Altitude."

CONTINUED development work is providing man with necessary preventive and compensatory means to overcome the four chief barriers to his ascent into ever higher altitudes. These chief barriers are in the areas of:

- Reduced barometric pressure
- Velocity
- Vision
- Radiations

Reduced Barometric Pressure

The most significant effect of reduced barometric pressure is the reduction in partial pressure of oxygen. If that concentration drops below a minimum, living processes deteriorate.

Historically, man's adjustment to reduction in oxygen pressure at altitudes has proceeded along the following course:

Oxygen could be demanded from a gaseous source by a pipe-stem arrangement which would increase the percentage of inspired oxygen as the breather desired. A long standing altitude record was reached by this method. This was refined by the development of masks to obviate the undesirable features of the pipe-stem.

Because the demand might become excessive requiring an unreasonable amount of gaseous oxygen to be carried in the airplane, attention was directed to providing an automatic means by which the percentage of oxygen could be increased in accordance with the relative deficiency at increasing altitude. This resulted in the diluter-demand type of equipment.

When flight altitudes began to exceed the altitudes at which 100% oxygen upon demand was inadequate, the pressure-breathing type of equipment came into being. This provided for an additional 5000 ft. As still higher altitudes were anticipated methods of pressurizing the cockpit have been designed and constructed.

One feature of reduced pressure at altitude which presents a barrier apart from the reduction of oxygen pressure, *per se:* when the total pressure is reduced to a value below that at which gases will continue to remain in solution in the fluid blood, *boiling* will occur. This destroys the hydraulic functional capacity of the blood and causes vacuolation in the tissues.

This can only be met by preventing reduction of total pressure below this level. It has become traditional to consider this reduction to occur at 63,000 ft.

Another significant feature is the *sudden* reduction of pressure. This is called "explosive" decompression. If the body is suddenly exposed to decompression of significant amplitude two physical forces become active: the oxygen pressure is suddenly reduced and gases contained in the body rapidly expand. The former can be somewhat prevented by providing for a high level of oxygen saturation in advance of and during the event.

The rapid expansion of gases in the body can produce irreversible damage by rupturing body tissues, particularly in the lungs. This will be seen in damage to the lungs if the expanding gases cannot escape through the air passages.

Adaptation to reduced pressure and temperature changes at altitude can be accomplished by providing an artificial environment (a pressurized cabin) in which:

1. Oxygen pressure can be preserved, and
2. Temperature and humidity can be maintained at levels consistent with the flier's needs.

But this pressurized cabin and its components must be reliable! Such realistically reliable cabins can completely obviate the need for carrying additional oxygen and furnishing cumbersome personal equipment.

When our altitudes exceed those at which air is available for compression to furnish pressurization and ventilation, we will be required to take with us

the required components. These requirements can be reduced to oxygen alone which can be provided in liquid form. Undesirable accumulations of the products of living can be disposed overboard. This means, in substance, that we can surmount the altitude barrier even to those outside the earth's atmosphere.

Velocity

Speed, velocity, per se, has no physiological significance. It is only when velocity changes in vector or magnitude that it becomes significant.

There is, however, one very important corollary of speed. Flight requires that the flier be aware of where he is, where he is going and what he should know to make correct decisions about his actions. In this respect man has a finite impediment. Speed of vision, time of decision and time of reaction are built-in limitations.

To illustrate, it is calculable that if two aircraft approach on a collision course, each at a speed of 600 knots, and their presence does not enter the consciousness of either within a mile's range, they will collide before either can humanly initiate change of course to avoid collision.

We have learned to fly under instrument conditions. But we have reached a point at which a very careful, realistic, new approach must be entertained. Present day instruments are not much more than glorified steam gages. They require considerable study for reading and even more exacting translation to determine what they are trying to tell.

Fortunately, improvement in data presentation is progressing rapidly . . . and we can look forward confidently soon to means of learning essentials in time to make them useful.

But improved data presentation is not enough. Flying at increasing speeds is so exacting and so demanding that the expenditure of great effort and extended time in the performance of the minutiae of the task is not tolerable. This is particularly true for the military aviator. To him his airplane should be only a point of vantage from which he can practice his profession of arms. To have his talents and abilities available for this professional application he must be relieved of the details of placing and maintaining his airplane in an advantageous position. When we have developed and installed such means we will have met and surmounted this barrier.

In flight, an airplane becomes to all intents and purposes a celestial body. Its velocity and controls make it possible for it to alter the vectors and magnitudes of its *gravitational forces*.

The study of gravitational influences on flight embodies a combination of an understanding of the basic physics involved and the biological results of these physical forces. Of Newton's three laws, the second and third are most significant. The second states that acceleration is directly proportional to the unbalanced force causing it and inversely proportional to the mass of the body. The third law states simply that for every action there is an equal and opposite reaction. Application of these laws to analysis of the gravitational forces developed in flight results in precise definition of the forces to which the human occupant is subjected. . . . But the biologist must express his findings in approved physical terms and the physicist must appreciate the biological point of view.

Four aspects of gravitational forces which are significant in considering the biological, physiological effects: the direction, the magnitude, the onset, and the duration of the acceleration.

In physiological thinking it should not be permitted to consider acceleration without amplifying qualifications in these four aspects. To say that a flier is subjected to so many *g*'s is not sufficient. To evaluate the potential physiological response it is necessary to state, further, that the *g* comes on so fast, applies along such axes, and lasts so long. (It has been determined that man is tolerant of much higher accelerations if they last for short periods of time and if they apply transversely rather than longitudinally. Other illustrations can be compounded by casual contemplation.)

The four aspects are critically significant. Many of the barriers presented by gravitational forces have been surmounted. Devices have been developed which increase human tolerances and there has been a considerable increase in the basic knowledge which will point to other means of meeting the challenge.

The highly dynamic vibratory response to accelerations of rapid onset should be given increased attention. This aspect is noted in the rapid decay of acceleration in crash impacts, in the impact on suddenly encountering high air pressures, in the termination of high sink rates, and in the sudden application of force to separate the occupant from an airplane in distress. These sudden impacts result in dynamic responses which attain to magnitudes in multiples of static stresses. They must have tremendous biological import. There is a growing accumulation of facts in this area but there are still many aspects that require solution before we can say that this barrier has been met.

Absence of acceleration is enjoying increasing interest of late. This is the condition known as "weightlessness." This is best understood by the application of d'Alembert's principles of equilibrium among forces. When the gravitational, inertial, and resistive forces are in equilibrium the result must be zero. This will prevail in the glide trajectory of a rocket-propelled vehicle and particularly in space travel where these equalities can be easily established in the absence of resistive drag. Until it becomes possible to establish this situation under laboratory control conditions, the physiological effects of this condition of weightlessness must remain somewhat conjectural. So long as any "weight" remains in terms of fractions of *g*, results will be essentially meaningless. So long as there is any *g*, there will not be weightlessness.

Some results of weightlessness must be accepted as *a priori*. For instance:

- Physiological processes which are influenced by gravitational force, such as locomotion, will be materially affected.
- Muscular effort required to rise from a sitting posture will be infinitely less than that required in ordinary terrestrial existence.
- Objects under contemplation and in use will not fall.

- Fluid will not run out of containers into the mouth.
- Thermal convection will cease with stagnation of expired air before the face.
- Many other normal functional procedures will be altered.

Most of these results can be surmounted by rationalization and practice . . . and by interposition of mechanical means. There remains, however, only conjecture as to the influence of weightlessness upon the functions of special orientation. Will the absence of normal gravitational influences upon the labyrinth in the inner ear result in illusions of the location of other objects in space? Will apparent distances be altered by the resultant distortion of proprioceptive neural mechanisms? The answers to these questions must remain in some doubt until weightlessness has been experienced for durations long enough to make scientific observations.

Although the barrier presented by gravitational forces has been partially met, there remain a number of areas which require further exploration.

Vision

The importance of providing improved data presentation and relief from the complexity of interpreting present instruments does not involve vision exclusively. There should be increased sharing of the responsibility among all the senses. Certain data can best be presented to hearing and certain others can be sensed by the proprioceptive senses.

Other aspects of the problem faced at higher altitudes are essentially astrophysical in nature. The first has to do with the change in sky brightness at altitudes. The second relates to the reduction in diffraction. A third is called "empty field myopia."

SKY BRIGHTNESS diminishes with altitude. This is more noticeable at the zenith than at increasing angular declinations from the zenith. This reduction in sky brightness is discernible at altitudes as low as 40,000 ft and increases so that the brightness of the sky at 100,000 ft is about 1/30 the value at 10,000 ft. At 450,000 to 500,000 ft the zenith brightness approaches that of a moonless night at sea level. The import of this fact is its effect on navigation because at the higher altitudes celestial bodies will be available for sighting during daylight hours.

REDUCTION IN REFRACTION shows its influence primarily in its effect on contrast. The absence of dust, vapor, and ice at higher altitudes causes light rays to progress without diversion. Thus, the contrast with areas not illuminated by the direct rays is accentuated.

Two physiological effects result:

1. The contrast level can attain a value which exceeds the comfort level;
2. Objects in the cockpit not exposed to direct solar illumination will be invisible.

The solutions to these situations are simple in concept. Filters can be interposed to reduce contrast . . . and cockpits can be floodlighted to make the instruments visible. Accordingly, these attributes of brightness at higher altitudes should not seriously impede adaptation.

EMPTY FIELD MYOPIA results when there is no object in space to provide a reference for focusing the eyes. The normal eye cannot focus beyond optical infinity, and when it views an empty visual field the average focus is nearer than infinity so that the normal eye becomes, under these circumstances, virtually nearsighted. The farsighted eye will focus beyond optical infinity and the nearsighted eye will become more nearsighted. The result is that objects may appear in the field of vision but be so out of focus as to be undetectable. Further, the absence of sharp focus in the absence of other reference points may seriously distort orientation and distance estimation. A solution to this situation may depend upon providing a projected image for reference purposes.

Radiation

Radiations emanating from the sun are increased in concentration as man escapes from the blanket of the earth's air. These, and rays from unknown sources and man-made sources, can present a barrier to flight at higher altitudes.

Ultraviolet rays from the sun are largely impeded by the atmosphere. The absorption of ultraviolet rays by ozone is enormous with the result that only an infinitesimal fraction of the rays reaches the surface of the earth. The concentration of ozone declines rapidly at altitude so that at altitudes at which flights are regularly conducted the concentration of ultraviolet rays is high enough to be of physiological consequence. Whether they will be found to be of sufficient concentration to cause irreversible damage has not yet been established. It may be necessary to interpose filters to reduce the threat of serious damage.

Solar X-rays, alpha and gamma radiations will probably not attain harmful concentrations at altitudes within the air layer. Above these altitudes, in space travel, they may attain to highly significant concentrations. Alternately presenting reflecting and absorbing faces of the vehicle will constitute an attractive means of temperature control.

Radiation from the heavy nuclei of the primary cosmic radiations can be significant at higher altitudes particularly outside the atmospheric layer. Present thinking leans toward the concept that they may not be biologically significant except after long exposure. The idea that cosmic radiations may constitute a serious barrier has resulted more from uncertainty of the unknown than from proven harmful effects.

Protecting Personnel

With the introduction of nuclear power for flight, protection of personnel becomes a barrier.

Protection of the personnel in the vehicle may constitute a lesser problem than the protection of maintenance and operating personnel. There are strong reasons to believe that with present knowledge and the awareness of the potential danger nuclear powered vehicles will not be placed in service until all precautionary means and methods have been provided.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Cavitation Erosion in

CAVITATION erosion or pitting of the water side of diesel-engine cylinder liners can be alleviated by such means as:

1. Adding a corrosion inhibitor to the water.
2. Reducing the vibratory stresses in the affected areas.
3. Making the liner out of a more erosion-resistant material.
4. Coating the liner surface with a more erosion-resistant material.
5. Increasing the water pressure.

In many cases, the use of more than one of these methods in combination results in an even more worthwhile improvement in the liner condition.

Corrosion Inhibitors

Adding small quantities of certain substances to the coolant may help reduce the cavitation erosion rate of the liner. So far, only two—soluble oil and chromates—have been found sufficiently helpful, both giving about the same degree of overall protection.

The soluble oil is used in concentrations of ½-2% in water, but it is actually relatively insensitive to concentration.

The chromates, on the other hand, appear to be quite susceptible to both over and under dosage, so that they must be used with great caution. For instance, some operators found that addition of insufficient chromates to stifle oxygen-type corrosion of iron completely will cause serious intensification of the attack.

One investigator found that good protection is maintained with a chromium content of 31–32 mg per 100 ml and the alkalinity (pH factor) at 9.5–10.5, as recommended by the manufacturers. Another investigator expressed the effective concentration limits as 1000–2000 ppm of chromate inhibitor.

Others found that chromates will offer protection

The Authors

THIS article is based on the following papers presented at a "Symposium on Cavitation and Corrosion in Engine Cooling Jackets."

"Cavitation Control through Diesel-Engine Water Treatment"
by W. Margulis and J. A. McGowan
Alco Products, Inc., and
W. C. Leith
Dominion Engineering Co., Ltd.

"Study of Cavitation Erosion"
by Bernard Trock
Materials Branch, Research & Development Division, Detroit Arsenal

"Investigation of Cavitation Erosion in Diesel-Engine Coolant Systems at U. S. Naval Engineering Experiment Station"
by Alan R. Schrader
U. S. Naval Engineering Experiment Station

"Reduction of Cavitation Pitting of Diesel-Engine Cylinder Liners"
by J. A. Joyner
Internal-Combustion-Engine Section
Government and Industrial Products Division, Studebaker-Packard Corp.

"Coolant Side Corrosion of Diesel Cylinder Sleeves—Means for Reducing"
by A. K. Blackwood
International Harvester Co.

Each of these papers is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ each paper to members; 60¢ each paper to nonmembers.

Diesels Can Be Reduced

only if the vibration amplitude is not too great. Further, one aluminum manufacturer does not recommend the use of sodium chromate in an aluminum-iron system, such as an aluminum cylinder head and a cast-iron block. To avoid this, an inhibitor consisting of 28.35 g sodium nitrite, 13.1 g sodium nitrate, and 18.9 sodium dihydrogen phosphate was tested in an engine. There appeared to be some improvement, but some liners were slightly pitted, indicating that this was not the cure.

Operators were also cautioned about the use of the chromate treatment with antifreeze. It has been found that where chromate-treated water is used with certain permanent antifreezes, heavy deposits are formed in the hottest areas of the water jacket, with resultant increases in metal temperature in these areas.

Reducing Vibration

It appears that resonant vibration of the cylinder liner as excited by the impacts of piston slap and cylinder firing pulses is one of the important factors in causing cavitation erosion. Thus, any measures that can be taken to reduce it bring important dividends. In fact, it has been found that no material can resist pitting if the amplitude of vibration exceeds 0.003 in.

Two ways to reduce vibration of the cylinder liner are:

1. Reducing piston clearance.
2. Increasing liner wall thickness.

Vibration tests have indicated, for example, that liner wall vibrations can be reduced from slightly over 0.006 in. for a thin-wall (0.156 in.) liner with a production piston to less than 0.001 in. for a 2-piece heavy-wall (0.25 in.) cylinder with a piston having 20% less clearance.

Liner Materials

Use of a harder or more corrosion-resistant material for the liner also lessens cavitation erosion.

Table 1 shows that harder aluminum alloys tend to be damaged less by cavitation than softer alloys, under the same conditions.

Similar data are presented in Table 2 for a group of other metals of various hardnesses. Note that stellite has a much smaller weight loss than any of the softer materials.

The cavitation erosion being experienced in the field on a certain make of diesel engine was reported to be completely eliminated with only a change in material to copper-chromium-iron. No case of corrosion has been observed in laboratory engines since the change was made in 1949, and field complaints have practically ceased.

Coating the Liner Surface

Both nonmetallic coatings and plating of various types have been found helpful in reducing cavitation erosion. Some of these are:

1. Nickel-chrome plate.
2. Copper plate.
3. Neoprene coating.

One investigator has best results with 0.003 in. nickel plate plus 0.010 in. chrome. Another one found that a plate of 0.003 in. nickel and 0.005 in. chrome gave considerable corrosion resistance. Particularly good results were also obtained with self-regulating chrome plate, it was felt, because of the

Table 1—Cavitation Weight Losses of Various Aluminum Alloys Tested under Similar Conditions

Aluminum Alloy	Hardness Brinell 500 Kg	Specimen Weight Loss Rate, mg/hr
2SO	23	120
2SH	40	106
61SO	40	36
355	74	24
61ST6	96	21

Table 2—Pitting Resistance of Several Materials

	Loss of Weight in 120 Min, mg
Rolled Brass	215.0
Mild Carbon Steel	70.0
18-8 Stainless Steel	From 8 to 35
Cast Ampco Bronze	6.0
Stellite	0.6

Table 3—Effect of Pressure on Cavitation Rate at 170 F

Pressure, psi gage	Cavitation Rate, g/120 min		
	Distilled Water	Chromate, 200 Fpm	Soluble Oil
0	0.038	0.029	0.013
10	0.031	0.030	0.010
20	0.026	0.008	0.009
30	0.018	0.007	0.008

fact that it has about 3000 grains per sq in. as compared with 720 grains per sq in. for conventional chrome plate.

In using copper plating, it was found to be important that the copper be properly bonded to the sleeve surface.

Increasing the Water Pressure

Keeping the water pressure high helps the cavitation problem because it reduces the opportunity for cavitation bubbles to form. There is also, however, a contradictory effect in that when the driving force is sufficiently extreme to create vapor conditions, the bubbles will collapse with greater violence, due to the higher driving pressure.

Table 3 shows the results obtained while maintaining a constant temperature and varying pressure. In all cases there was a decrease in weight loss with each incremental increase in pressure. (While it would have been of considerable interest to determine the pressure levels that could completely stop cavitation from taking place, this was not possible with the equipment at hand.)

Nuclear Advances . . .

. . . are under way in all fields of engineering where SAE members do their work. Ground, air, and underseas propulsion advances are only part of rapid progress of concern to automotive engineers.

This article is based on recent discussions at a meeting of SAE's Nuclear Energy Advisory Committee.

TECHNICAL advances growing out of nuclear developments are under way in nearly every engineering field in which SAE members are active.

Researches and studies on nuclear propulsion are continuing in connection with ground and air vehicles, as well as on submarines.

- Success of the Nautilus and the Sea Wolf, first atomic-powered subs, points to atom power for all U. S. undersea boats and elimination of the diesel as a submarine powerplant.
- Studies on nuclear locomotives are moving fast. One set of studies may be completed within the next 30 to 60 days.
- Researchers on nuclear propulsion for aircraft, while pushing ahead, must learn more than they know now about radiation effects on organic and metallic materials. Electronic and high-temperature resistance to radiation also has to be probed further.

The same radiation which is troubling the propulsion researchers is being harnessed for good ends by researchers in other fields.

Laboratories for instance, are well along on the trail of processing for upgrading gasoline and diesel fuels by irradiating them. . . . And the coal industry finds it may be able to use radioactivity to upgrade lignite to bituminous coal. Radioactivity may also make it possible to release new chemicals from coal.

SAE nuclear experts agree that the nuclear reactor field awaits the development of a really good nuclear fuel element. Says one: "When this business settles down, some one will develop a practical process for fabricating fuel elements and a standardized design for them. We just can't continue to advance by relying on tailor-made fuel elements."

In other areas, thickness gages using isotopes now make it possible to control steel sheet thickness more accurately than ever before. In oil refining, radioactivity may become a useful energy source for catalyzing reactions. In both the laboratory and in the field, petroleum companies find radioactive tracers to be useful tools.

The railroads, whose engineers have been showing increased interest in SAE diesel activities also, are active in nuclear areas other than that of locomotive propulsion. For one thing, they are replacing all switch lamps with markers coated with krypton. These lighting markers, railroad men say, will last 12 years without any maintenance. Radiation is proving useful, too, in locating rail imperfections and fractures.

Much new knowledge of metallic structures also is accruing from current studies of radiation damage to materials.

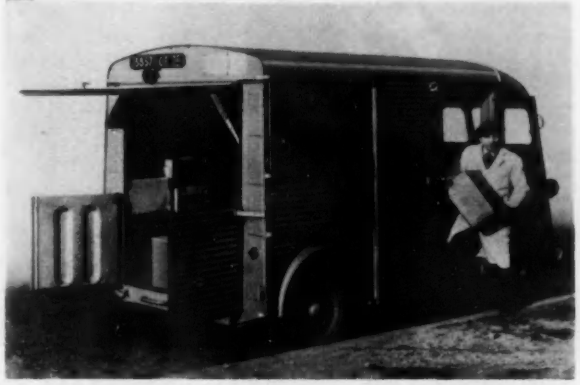
Members of the SAE Nuclear Energy Advisory Committee, from whose discussions were drawn the developments mentioned in this article, are: Dr. C. R. Lewis of Chrysler, chairman; Dr. L. R. Hafstad, General Motors; Dr. A. A. Kucher, Ford; J. J. Grebe, Dow Chemical; Ray McBrian, Denver, Rio Grande & Western R. R.; E. D. Reeves, Esso; Dr. J. B. Austin, U. S. Steel; and D. R Shoults, General Electric.

Europe Takes to Light Trucks and Buses

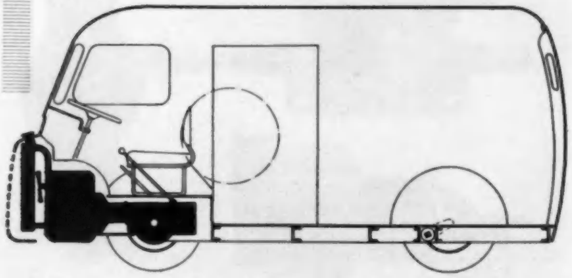
Ludwig G. Boehner
Chief Engineer, Volkswagonwerk, Germany

Based on paper "Light Trucks and Buses in Europe."

BEDFORD-DORMOBILE micro-bus has a rear passenger entrance. Seats can be folded away sideways to free loading space. Van and pickup models are also produced.



CITROEN Type H 1½-ton van has front-wheel drive to give a low, easily loaded platform. It features individual wheel suspension with torsion rod springing front and rear, and integral chassis construction.



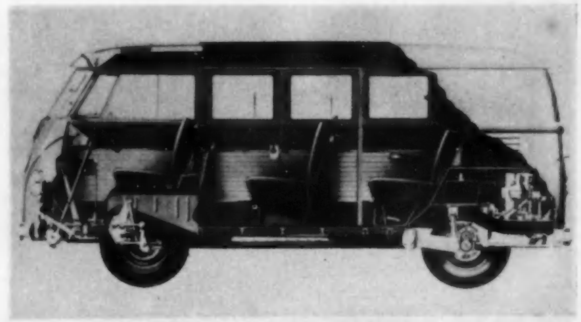
PEUGEOT D4 1¼-ton van carries 70% of curb weight and 50% of fully loaded weight on front axle. Front suspension has 25 torsion rods, each 8 mm square, while rear has 49 rods, each 7 mm square. These are arranged in pairs, parallel to vehicle axis in front, crosswise to axis in rear.

An intermediate type of commercial vehicle is zooming in Europe. It carries payloads ranging from 1000 to 3000 lb, or 8 to 14 passengers. Some feature a front-wheel drive, others employ the orthodox front-engine, rear-wheel drive, and one has a rear-mounted engine with rear-wheel drive. Most of them have engineering innovations.

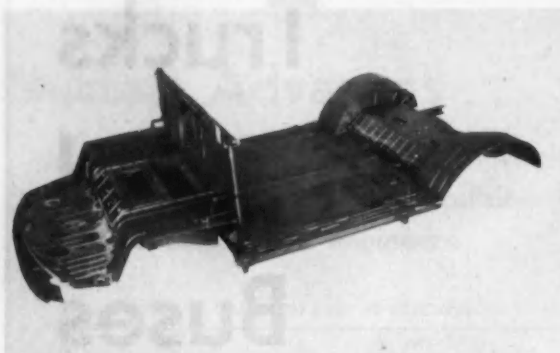
The advent of the light truck and bus is a postwar phenomenon. At the close of hostilities the European railroads were in chaotic state, automotive fuel was scarce and high, and truck tires were almost unobtainable. The light weight truck of the pre-war era could not handle needed transportation, consuming as it did an entire month's fuel ration in a week. And so the cry went up for fast, economical trucks.

Truck manufacturers were slow to heed the cry. They lacked faith in the market and capital. So the forerunner of today's intermediate type of truck came from small factories and body plants. It was built in small volume on passenger car chassis and from the drive units of the then popular three-wheel delivery vehicles. Because the latter were

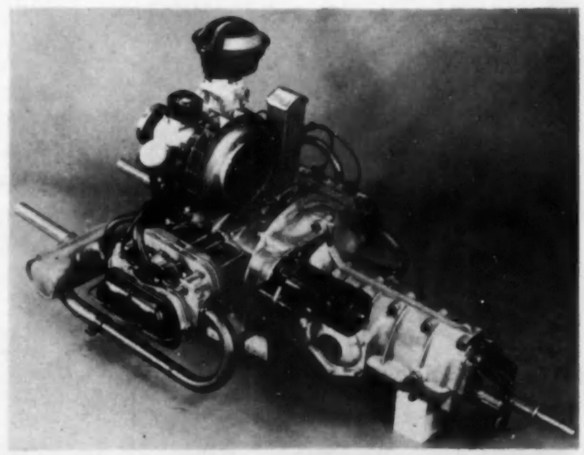
Engineering Details of Volkswagon Commercial Vehicles



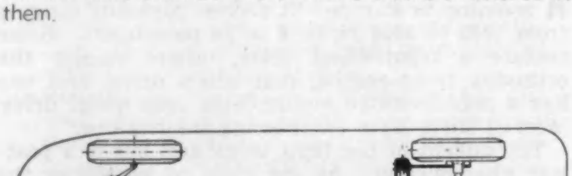
CUTAWAY of 8-passenger micro-bus shows engine location behind rear axle, giving near equal loads on axles. Overall design was developed in wind tunnel to get best fuel economy at maximum speed which is 60 mph. Truck models are identical in all essentials.



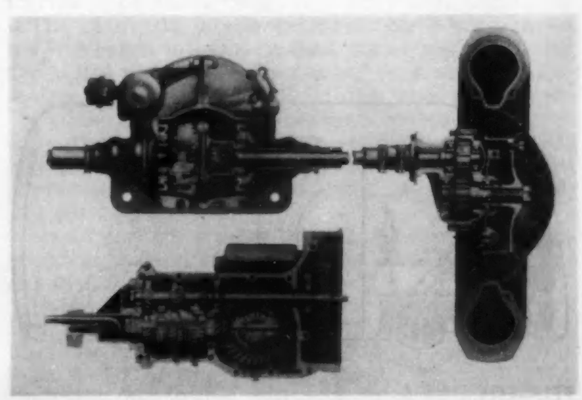
FLOOR ASSEMBLY of van which carries 2000 lb payload and has 2099 lb curb weight. Light weight is achieved by frameless construction with upper structure a rigid, skin-stressed box. Floor carries shallow longitudinal ribs. Light weight cross-members are spot welded to them and distribute load between lower edge of the body side panel and the longitudinal reenforcing channels to which they are welded at either end. Axles and powerplant are carried on these channels and on frame brackets fastened to them.



POWERPLANT without air ducts or housings. Use of magnesium for housings in place of cast iron of equal thickness saves 110 lb in engine weight. The 72.7 cu in. engine has a rating of 36 hp and weighs 210 lb with clutch, starter, exhaust, and aircooling systems. Complete weight is 270 lb.



INDIVIDUAL SUSPENSION and torsion rod springing features all four wheels. There are two trailing arms on each side of the front, carried in plastic bushings and sprung by two bundles of torsion rods completely sealed. Rear wheels are similarly connected to a trailing arm and suspended by a round, sealed torsion rod.



GEARING in rear wheels adds 3 in. to road clearance and increases overall gear ratio between engine and rear wheels. This was done to make possible use of the engine and transmission from the lighter VW passenger car.

weak and low in horsepower, they were far from satisfactory.

Then came the first volume-built light truck with an engine developing 15 to 30 hp, capable of carrying a 2000-lb payload at 50 to 56 mph with a gasoline consumption of 19½ to 23½ mpg. Out of this grew the combination wagon which could transport people or goods, and finally the small, light luxury bus, or micro-bus, as it has come to be called.

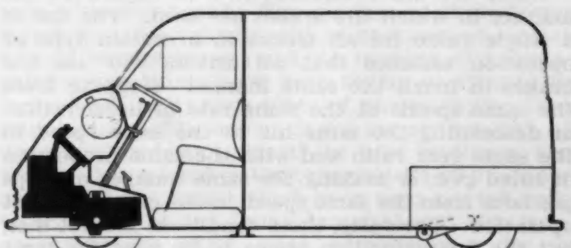
The uses to which the combination truck, or Combi, is put are legion. In addition to delivering merchandise, it is used by post offices, police, radio stations, contractors, commercial travelers, and farmers. Micro-buses are used by travel agencies, airlines, hotels, rental agencies, sport clubs, road shows, and for camping. With special equipment they serve as ambulances and for flying police squads and fire brigades.

Germany is the great exponent of the light truck and bus. Five German concerns are building light trucks having a gross vehicle weight of 3620 to 4950 lb, with a loading space varying from 162 to 212 cu ft. Six concerns are building micro-buses having outside dimensions no larger than the medium sized European passenger car and as easily handled. The wheelbase is approximately 95 in., the overall length runs between 154 and 177 in., and the greatest width is approximately 69 in.

Three of the six manufacturers build four types having front-wheel drive. They prefer to have special chassis frames on which the bodies can be assembled. The other three build bodies of frameless construction. Two use a front engine with rear-wheel drive, while one, the Volkswagonwerk, places the engine in the rear.

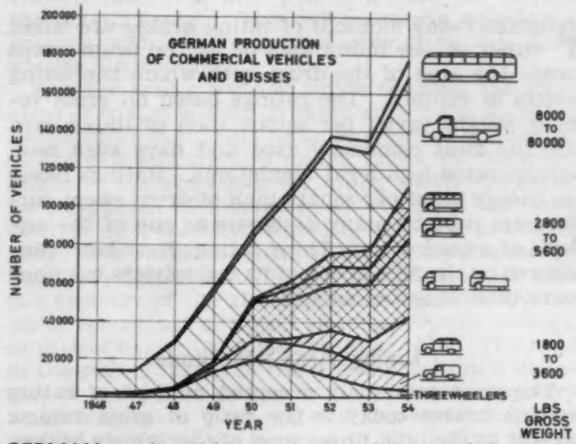
Basic considerations in design have been safety and loading space. Good visibility, roadability, and cornering characteristics, plus well considered weight distribution make for safety. By means of forward steering, light-weight construction, and many unorthodox details such as torsion rod springing, individual wheel suspension, and frameless construction, vehicles have been created with nearly three times as much loading space and nearly twice as much carrying capacity as comparable vans built on passenger car chassis.

(Paper on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



DKW has engine ahead of front axle and driver's seat behind. All other German vehicles put seat above axle. This design permits loading platform to be close to ground without sacrificing clearance.

ALPHA ROMEO "Auto Tutto" truck has front-wheel drive with a 2-cyl, 2-cycle diesel of 30 hp located ahead of the front axle. Payload is 2200 lb and gross vehicle weight 5060 lb. Micro-bus for 10 passengers has 4-cyl engine of 35 hp.



GERMAN truck and bus production data reveal the growing popularity of the light pickup truck, combination wagon, and micro-bus—the fourth, fifth, and sixth curve from the bottom, respectively.

FORD FK 1000 micro-bus shows excellent streamlining. German producers put great stress on good aerodynamic design to obtain maximum fuel economy.

How Brakes Are Rated Using Lining Area and Drum Swept

R. L. Wehe, Cornell University

Excerpts from paper, "Brake Ratings for Automotive Vehicles."

PRESENT-day methods of rating brakes are based either on the lining area or on the drum swept area—the area of the drum with which the lining comes in contact. The ratings based on gross vehicle weight (gvw) per square inch of lining area are the most commonly used and have even been incorporated into legal regulations. Ratings based on energy input per square inch of drum swept surface are used by many designers as one of the criteria of a good design. These ratings have been considered by the SAE in one of its committees but none have been accepted as yet.

"Lining Area" Methods

The most commonly accepted method of rating vehicle brakes today is the ratio of gross vehicle weight to the total lining area of the vehicle brakes. Not only is this value used by the manufacturers and operators but a number of legal bodies have accepted this method of rating. The use of this figure stems from the ready availability of the values on which the rating is based and from the fact that most brake troubles are concerned with the lining. Both the gvw and the total lining area are given in most summaries of vehicle specifications. Furthermore, the method will give as good results as any rating method which has yet been proposed if certain limitations are met.

The first limitation has to do with the relation of the lining area on each axle to the braking effort developed there. If the ratio is constant for all brakes on the vehicle, the total values of weight and lining area will have the same ratio as will the values for any axle. The braking effort is the decelerating effort developed at the road. In the case of air brakes the braking effort will be proportional to the area of the air cylinder times the slack adjuster length (*AL* factor) if the tire size, drum size, cam size, and lining coefficient are constant throughout the vehicle. For brake systems generally it will be proportional to the energization factor if the tire size, drum size, and lining coefficient are constant throughout the vehicle. It should be emphasized that the braking effort distribution is set by the designer and does not vary with varying weight distribution either from loading or from weight shift with deceleration. There is a possibility that some standard should be developed to guide the designer in his selection of the braking effort distribution as related to the weight distribution and the weight shift due to deceleration, and taking into account the various road surface conditions which may be met in operation.

The second limitation has to do with the extent of lining per shoe and the number of shoes per brake. If the lining length per shoe is held to approximately 120 deg, good use is made of all the lining. If appreciably more than this length of lining is used per shoe, the load rating given to this brake will be too large since, due to the varying pressure distribution and wear distribution on the lining, the added lining area does only a fraction of the work done by the lining in the center of the shoe. With an arbitrarily set lining length and only two shoes per drum, the lining length and area would be roughly proportional to the brake swept surface, which will be discussed later. Where more than two shoes are used, the rating will be somewhat in error since the drum temperature and therefore the wear rate will be higher for a given rating. This is the result of the energy input rate being increased while the heat dissipation capacity for a given temperature remains the same or perhaps even decreases if open-type brakes have been used.

There are other limitations with regard to the manner in which the brakes are used. The use of a single value for all trucks in a certain type of operation assumes that all drivers will use the brakes in much the same manner—stopping from the same speeds at the same rate of deceleration, or descending the same hill at the same speed in the same gear ratio and with the same proportion of rated gvw, or making the same number of stops per hour from the same speed, in the case of transit operation. Obviously, these conditions are not met, but the approximation seems to be good for most vehicles.

It is seen then, that this method can give reasonable results, but it has one great shortcoming if the lining length is not limited. Whenever a brake designer finds that he cannot provide sufficient lining

Area Methods

area in the method which he knows to be best, he may add lining area by increasing the angle of lining, or by placing large drums on the front wheels where they cannot be used fully, due to steering difficulties which would arise. This practice would most likely result where the designer was faced with a legal requirement for a certain ratio. This practice is not the general rule, fortunately, but there is nothing in the present use of the method to prevent this type of abuse.

"Drum Swept Area" Methods

A second method of rating brakes on the basis of lining area is one which takes the average unit pressure on the lining, as exerted by the actuating mechanism, as the basis of design. This method has not had common acceptance because the values on which it is based are not readily available to many people. The method has the advantage of giving a value which has a direct effect on the wear rate, but it has most of the shortcomings of the first method.

There are at present no official rating methods based on the drum swept area, but a number of the authorities in the field have developed relationships which relate the gross vehicle weight to the drum swept area. This expression is related to work and energy, but some of the terms are missing. The missing terms have to do with the magnitude and rate of energy input. The absence of these terms infers that the vehicles will be operated at similar critical energy input rates. A number of vehicle-category constants have been set up to attempt to include all the various types of energy inputs that might occur. The energy input per square inch of drum surface is an index of the heat loading of the drum. It is related to the temperature of the inner surface of the drum. This is in turn related both to the wear of the lining material and the fade, characteristics which often accompany a rise in temperature. There are a number of methods of applying this concept in developing a rating method.

The energy input per drum swept surface is also related to the heat dissipation ability of the brake in that the outside area is roughly in the same proportion to the swept area for most brake designs. This is fairly rough and there are several of the variables missing which do not allow for improved designs. (A more exact method of handling the heat dissipation ability of a brake is given in the complete paper.)

Perhaps the most direct method takes the kinetic energy of the vehicle and divides this by the drum swept surface. The question immediately arises as to how the kinetic energy is determined—at what speed or what speed change. The inability to establish a standard for determining the kinetic energy has held up the development of this system of rating. The condition of operation can be assumed, as has been done implicitly with the gvw per lining area or the gvw per drum swept area, but then this method has advantage only in that the designer cannot gain advantage by increasing lining area. A further refinement of this method takes another variable out of the rating by using the axle weight—for some assumed weight distribution and deceleration rate—and uses this as a basis for finding the kinetic energy. This will be correct only if the braking effort is made proportional to the same weight distribution.

Another rating method which contains the variables of energy and drum swept area is the so-called "work formula." This formula divides the product of the gvw and the tire rolling radius by the drum diameter squared times the lining width. This can be considered in a number of ways but the most general interpretation would be the gvw per drum swept area times the ratio of the rolling radius and the drum diameter. The gvw per drum swept area is a measure of the kinetic energy input for a given set of conditions of initial velocity, velocity change, or rate of descent and gear ratio on hills. The ratio of the rolling radius of the tire and the drum diameter is a measure of the lining pressure necessary to accomplish a given rate of deceleration. It is readily seen that an increase in the rolling radius or a decrease in the drum diameter will call for an increase in the lining pressure to give the same braking force at the road. The results of this method are much the same as the one using kinetic energy per drum swept area but do not make apparent the assumed conditions of operation.

General Limitations

The analysis of present rating methods has shown that most of them will give satisfactory results for certain given conditions. The methods based on lining area can be abused but a limitation on the lining length would eliminate this abuse—another method of correcting much of the abuse is to use the projected length of the lining on the drum diameter. All the methods can be abused if the distribution of braking effort is not the same as the distribution of braking area—lining area or drum swept area as the case might be. The use of more than two shoes will show an increased rating when the lining area methods are used. The true improvement is less than might be expected, since the drum temperature will depend mostly on the drum configuration and so the brakes will operate at a higher temperature with the increased input rate. In open-type brakes the addition of another shoe

Continued on page 78

Precision Forging Tomorrow's

. . . will eliminate weight and machining

TOMORROW'S supersonic military aircraft will experience temperatures necessitating the use of new design, heat-resistant alloy airframes. Because of the machining and weight problems associated with these alloys, more accurate forgings will be required. This will increase the cost of the forgings but, in many cases, finished-part cost will be less than at present. New forging techniques, however, will present temperature, die material, equipment, and lubrication problems.

As aircraft approach the thermal barrier, skin materials and portions of the airframe, because of air friction, develop heat. For example, the supersonic aircraft flying at a sustained speed of Mach 2.5 and at an altitude of 60,000 ft will experience boundary temperatures between 350 F and 425 F. Add to this the heat given off by the powerplant and the temperatures exceed the useful temperature range for aluminum and the light alloys.

To meet these higher temperatures, new airframes will have to be developed using steel alloys, titanium alloys, inconel alloys, and other heat-resistant materials.

One of the problems associated with these materials, however, is their poor machining rates. Specialized machines which can cut aluminum alloys at speeds of 15,000 surface fpm only cut stainless steel at 250 surface fpm. Examples such as this illustrate the need for close-tolerance forgings with little or no machining required.

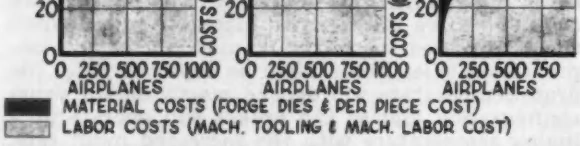


Fig. 1—Lower fabricating costs more than offset the increased development and tooling costs caused by forging to closer tolerances. The closer the tolerances, the greater the saving in finished-part cost.

The new materials being considered for the airframes weigh about three times as much as the present light alloys. The tolerances on components made from these materials, therefore, will be three times as important from a weight standpoint. Consider that a typical modern jet fighter, if built of steel, would gain approximately 65 lb for each 0.001 in. increase in skin thickness, and you get some idea of the magnitude of the weight problem. Since airframe forgings present much the same weight problem, we have another case for close-tolerance forgings.

Forging to closer tolerances, of course, increases the cost of the forging. But it is not the cost of any individual operation or series of operations which is important, but rather the cost of the final end product assembled in the airplane.

Fig. 1 shows the cost of a selected group of steel forgings designed as (a) conventional parts; (b) 2-deg-draft precision forgings; and, (c) zero-draft precision forgings. Note that in the typical conventional forging an appreciable amount of the total cost goes into machining the rough forging to a finished product. Let me inject here that a study of 28 typical conventional forgings, ranging in size up to 30 lb, showed that there was only 23% finished-part weight yield from the rough forgings. Thus 77% of the weight of the forgings was wasted in machining.

As we improve the rough forging and develop it as a 2-deg-draft precision forging, forge dies costs and per piece costs increase but machine tooling and labor costs decrease, resulting in a saving for the finished part.

With zero-draft precision forging, the forging development and die tooling costs are substantially increased but the fabricating costs are further reduced resulting in a substantial saving in the cost of the end product.

Many objections to machining forgings have been raised on the basis of insufficient capacity in case of an "emergency." This often can be substantially reduced by a post forging operation such as using hardened dies for coining certain areas.

Usually, small production does not warrant this added tool cost, and present day releases are often for small quantities. For this interim period, therefore, some machining is justified.

F. C. Pipher, Lockheed Aircraft Corp.

Based on the secretary's report of panel "Forgings—Steel and Titanium."

Airframe . . .

problems and lower finished-parts costs.

For the foreseeable future, the steel and titanium aircraft forgings will, in the main, be produced on impact tools. No serious compromise with metallurgical excellence will be required, provided metallurgical considerations are given first attention. It is believed that, for this same period, if extreme geometrical accuracy is required it will be best obtained by some post forging operation or operations.

Forging Temperatures

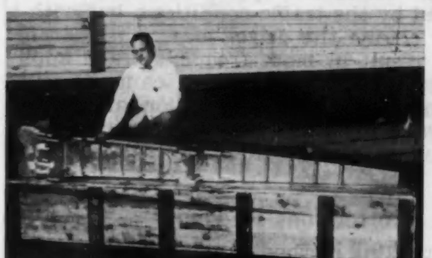
To meet the metallurgical requirements of tomorrow's forgings will require close control of forging temperatures. Present furnaces may prove inadequate in supplying this control and force the design of new and improved types of equipment. Controlled-atmosphere furnaces appear a certainty. For titanium forgings, especially, maximum temperatures will be critical and furnace atmospheres which prevent surface alloying and hydrogen pickup while heating will be required.

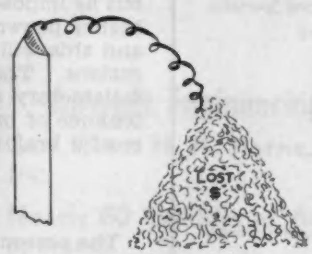
Where forgings are to be used without subsequent machining, techniques to eliminate surface decarburization and to improve surface finish will be mandatory. At times, machining the forging stock before heating may be necessary to remove surface defects and provide the desired finish. Or, maybe special surface coatings will be applied to the stock during heating to eliminate these defects.

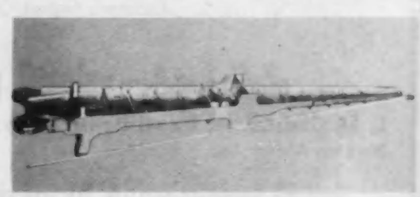
Die Materials

New die materials will have to be developed to withstand the severe stresses imposed by the intricate configurations of tomorrow's forgings. Die materials with high yield strengths and resistance to abrasion and galling will be needed for forging the high-strength, heat-resistant alloys. And, die

THE CASE FOR CLOSE-TOLERANCE FORGINGS







1000 lb - 800 lb = 200 lb

heavy press rough forging (steel-10 ft length)

of metal chips generated in machining

finished spar (steel-10 ft length)

materials suitable for the construction of segmented and insert-type tools, similar to those used in producing light-alloy precision forgings, will be required.

Forging Equipment

Hydraulic presses, drop and steam hammers, and mechanical presses will all find application in tomorrow's forging techniques. Hydraulic presses provide improved die life and better die alignment. They also permit the use of smaller draft angles and ejectors for the removal of forgings. Forging hammers permit repeated blows and reduced material time in the dies which prevents rapid chilling of the stock.

Lubricants

New lubricants will be needed to prevent galling, improve surface finish, and to assist in obtaining the precise geometries of tomorrow's forgings. New techniques for preparing the forging stock and possible methods for prelubricating the material should receive consideration here.

(This report together with 13 other panel reports is available as SP-317 from SAE Special Publications Dept., 485 Lexington Ave., New York 17, N.Y. Price: $2 to members; $4 to nonmembers.)

THE PANEL which led the discussion at which this article's information was exchanged consisted of:

Panel Leader

A. H. Petersen, Group Engineer, Design
Lockheed Aircraft Corp.

Panel Co-Leader

W. V. Stackhouse, Group Engineer, Design Standards
North American Aviation, Inc.

Panel Secretary

F. C. Pipher, Forging Specialist
Lockheed Aircraft Corp.

Panel Members

L. M. Christensen, Casting Design Engineer
Northrop Aircraft, Inc

S. R. Carpenter, Development Engineer
Convair Division, General Dynamics Corp.

J. F. Nelson, Chief Metallurgist
Kropp Forge

T. L. Swansen, Vice President, Manufacturing
Ladish Co.

W. A. Dean, Chief Metallurgist
Aluminum Co. of America

HOW BRAKES ARE RATED

Continued from page 75

may even cause an increase in wear rate at the original rating, since some of the inside heat dissipating area is covered and the brake will operate at a higher temperature. The experiments reported by R. K. Super ("Brake Designs and Methods of Rating Brakes for Commercial Automotive Vehicles," SAE Transactions, Vol. 54, May 1946, pp. 205–213.) demonstrated that the effect on the wear rate of the increase of lining pressure as the lining length was reduced was balanced by the decrease in temperature due to better cooling of the drum inner surface until the lining was made shorter than 90 deg.

One shortcoming of all the present rating methods is the failure to separate the energy conversion rate and the heat dissipation rate. This has in general resulted in all brakes being given the same rating regardless of their heat dissipation rate. A correction factor based on heat dissipation rate of the brake in a standardized test would serve to eliminate this inequity.

What to Recommend?

The provision of adequate brakes on vehicles has become a point of concern of various public bodies. It is easy to see why this concern has developed when reports are read of the results of brake failures. It is not so easy to determine a policy to recommend to these bodies.

It should be pointed out that no code of design can be exact in the prediction of operational temperatures or lining life since the designer has no control of the eventual vehicle operator and there are no legal limitations on truck speed on a downgrade or on the operator's use of the accelerator in bus operation. There is a speed limitation on the bus as imposed by the traffic conditions, but with a higher power engine the driver may "push" traffic and this will result in more frequent brake applications. Therefore, a good design cannot assure satisfactory operation. The operation and maintenance of brakes play as important a part in successful braking as does the design.

Corrections Needed

The present rating method of gvw per square inch of lining area would form a good basis of rating brakes if certain limitations and corrections are made. The limits of lining length should be specified and a correction used if the length is greater than the specified length. A correction should be made if the lining area distribution is not the same as the braking effort distribution. A correction factor should be allowed for designs which result in improved heat dissipation rates. With these limitations and corrections and an adequate breakdown of service conditions with the constants determined by experience, this system of rating will give reasonably good results.

SAE National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display

Hotel Commodore New York, N. Y.

- **Aeronautic Production Forum—April 2**

Sponsor: **G. M. Bunker**, Martin Co.
Gen. Chr.: **G. T. Willey**, Martin Co.

Six informal gatherings to exchange information on vital aeronautic production problems—Each group will have a panel of experts available all day to answer questions.

- **Forum Luncheon—April 2**

"Production—A new Look" by **Lieutenant General C. S. Irvine**, USAF

- **Aeronautic Meeting—April 3-5**

Gen. Chr.: **A. T. Gregory**, Fairchild Engine Division, Fairchild Engine & Airplane Co.

12 technical sessions with over 30 aeronautic papers

- **Daily Luncheons**

April 3—"Propulsion—Key to Aviation Progress" by **E. R. Sharp**, Lewis Flight Propulsion Laboratory

April 4—"Turbine Transport" by **J. H. Carmichael**, Capital Airlines

April 5—"Science, Space and Satellites" by **Rear Admiral Rawson Bennett**, Office of Naval Research

SAE Sky-Ball Dinner-Dance, 7:30 P.M., April 5

- **Aircraft Engineering Display—April 2-5**

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Nearly 60 Exhibits of Advanced Aeronautical Developments

Location: Grand Ballroom, Hotel Commodore

April 2-5, 1957

NEWS OF SAE

New Materials, New Processes Are High Among Production Aims

PROVIDING adequate personnel is today's most pressing production problem.

This is the concensus of 22 top manufacturing executives who attended the SAE Annual Meeting in Detroit. All are members of the Production Activity Committee.

The search for better materials, improved methods of removing, forming, and joining metal continues. But temporarily, at least, the manpower problem has taken the spotlight.

"People are our greatest problem," declared a Committee member who is in charge of manufacturing for a large passenger car producer. "And the shortage is not confined to engineers," he added quickly. "We need to know more about selecting engineers for development into management jobs. We're constantly trying to improve management skills. We need better technical skills at all levels—and, particularly, at the lower levels."

In-Plant Training Questioned

While some in-plant training and apprentice programs for supervisors, foremen, and workers have succeeded, others have been dropped, it was pointed out. Results of these efforts to develop technical and management skills within the company are not clear cut.

The proposal was made to investigate several of the better known training programs. The question was raised, "What has happened to the men who took our training program five years ago?" Such an investigation, it was argued, would produce more definite answers than we have today about in-plant training.

More than half of the top manufacturing executives attending the meeting asked specifically for more information on how to prepare engineers for management jobs. Nearly one-third are looking energetically for ways and means to improve worker productivity. The emphasis here is on ways other than new machines and new tooling for increasing productivity.

The concensus seems to be: new methods and new equipment can do part of the job. But we must still find ways to increase worker willingness and, hence, worker productivity.

How to Communicate

Communications naturally entered the discussion. Problems of oral versus written communications were discussed. Questions were asked about the effect of repetition and the use of telegraphic language in communications. The answer seems to be: no scientific approach to the problem is available.

There are some specific communications problems that need attention, according to these top manufacturing executives. These include improving in-plant communications, finding better ways to specify on drawings and blue prints, and speeding up manufacturing reports.

Providing more information of a nontechnical-management nature was recommended.

As always, production management is looking for ways to reduce the cost of manufacturing and maintenance. Automation will help to do the job—if it is properly evaluated in the beginning and if flexibility is built into the new equipment, it was suggested.

Auto executives have their eye peeled for the possibilities of using new electronic computers to control production. As yet, however, this is more a gleam in the eye of a far-sighted engineer than a reality.

New Tools Examined

New tools are always a major interest with automobile manufacturing executives. Currently getting the spotlight are ceramic cutting tools, new carbide cutting tools, plastic tooling, and the so-called "cookie cutter" dies. Where they can be used, "cookie cutter dies" have reduced tooling time and tooling costs to a fraction of earlier requirements. Some of these subjects will be further explored by papers or round tables at the June 1957 and January 1958 meetings of SAE.

Several facts seemed to be fairly well established about "cookie cutter" dies. Some parts won't "make." Some dies fail early. Others run a surprisingly long time. Cookie cutter dies have

New Overseas Information Committee

SAE COUNCIL has formalized as the SAE Overseas Information Committee an informal group under the leadership of SAE Past-President C. G. A. Rosen which was inaugurated a year ago. Purpose of the group—and purpose of the now-formalized committee—was to explore the best ways to increase the overseas content of SAE meetings and publications.

Members of the already-in-action Overseas Information Committee are: C. G. A. Rosen, Caterpillar Tractor Co., chairman; J. T. Dyment, Trans-Canada Air Lines; W. E. Jominy, Chrysler Corp.; D. P. Barnard, Standard Oil of Indiana; M. A. Thorne, General Motors Corp.; R. R. Burkhalter, Spicer Division, Dana Corp.; and W. K. Creson, Ross Gear & Tool Co.

Chairman Rosen has reported to Council that "this program will grow by evolution and that, from time to time, additional members will be added when special knowledge of specific activities is required." He reports also that:

"Consultants will be called in from time to time to lend their knowledge and provide information relative to their overseas experience.

"The Committee has been authorized by the Council to make use of all of SAE's available information-disseminating tools . . . meetings, SAE Journal, special reports to the Council, spe-

provided an answer to many problems that once had to be solved by nibbling and burning. Some pointed advice was given on the subject: if you want to try cookie cutter dies, don't put an experienced die man on the job.

Auto engineers are watching titanium and they are increasingly aware of the improvements being made in the properties of powdered metals.

Science Contributing to Manufacturing

Other subjects in which these production executives have expressed an interest are tape and card-controlled machine tools, and how to machine radioactive materials. They want to know more about the "building block" concept in machine tools which is aimed at promoting standardization and flexibility of machines that must be tied together as in a tranfer line.

Quality continues to be primarily a manufacturing problem but there has been some help from the current trend toward automation. Automatic production automatically requires more uniform parts. If the quality is not there, machines will not function automatically, it was pointed out. "Waste can cost more than engineering," was the way one executive expressed his concern about quality.

It is generally agreed that there is a pronounced trend toward automatic assembly of parts. There is also considerable interest in better ways to get materials to the assembly line and in the development of more efficient methods of taking scrap away.

Due to the pronounced trend toward automation, production men have, if anything, a keener interest than ever before in conveyors. They are also interested in what air conditioning can do to improve quality and its effect on workers.

Training for Production

Training men specifically for production has been a somewhat neglected field, it was argued by one member of the committee. "We train men for design but production men just slide in through the side door" was the way he put it. The need to train men specifically for production is urgent, it was generally agreed.

A somewhat different approach to the personnel problem was reported by a member of the Production Activity Committee. A correlation was made of outside technical interests wtih successful apprenticeships. Does he read technical magazines? Is he interested in radio, television, and so on? An outside interest in technical matters may be an even better indication of potential skills than the usual aptitude tests, it was suggested.

Materials Papers Aim At Mechanical Engineers

WHEN you're preparing a paper for SAE, think of the mechanical engineer.

This advice, offered by an experienced member of the Engineering Materials Committee at the Annual Meeting in Detroit, sums up the formula for successful communication by materials men with members of SAE.

Where this rule is followed, a broad range of subjects can be tackled successfully, it was pointed out. Even a subject like "Solid State Physics" can make an interesting paper—if it's well handled.

This suggestion was offered: the subject can be very technical—if the discussion of it is not too technical.

The outstandingly successful talk by Dr. L. R. Hafstad at an SAE luncheon in Detroit recently is an example of this, the Committee thought. Dr. Hafstad's subject was, "Basic Research and the Automotive Industry."

In addition to subjects like solid state physics, the Committee feels that not-too-technical discussions of subjects like, "What Physics Means to You" ought to be considered, provided the discussion is slanted properly toward the audience.

Included in a wide range of technical subjects considered by the Materials Engineering Committee at its January meeting were the fatigue resistance of metals, accelerated laboratory tests, brake lining problems, steels that get their color electronically, new paints and finishes, and curved glass as a construction material.

While no action has yet been taken to put these subjects on the program, the Committee will be following developments in these fields. When significant developments occur, efforts will be made to tell the membership of SAE about them.

Several papers are in preparation on the subject of fatigue, both in SAE and in other scientific groups. Announcements may be expected in the near future.

The problem of producing valves made entirely of non-strategic materials has been a concern of automobile engineers for a number of years. A paper on this subject will be given at the SAE Production Meeting at Buffalo in March.

The engineer always has some reservations about the ability of accelerated tests in the laboratory to predict serviceability of a part. An area where this problem is particularly acute is non-ferrous materials. Lack of standardization and other factors have findings being presented to the industry. A member of the Committee suggested some industry work ought to be done.

Heavier cars and higher speeds have increased the loads on brakes to a point where brake designs and brake lining materials have become a subject of intensive investigation. Plastic binders for brake linings, for example, are being subjected to conditions on the freeways that present unusually difficult problems for the brake engineer. A considerable amount of research work is going on in this field, it was revealed.

The demand for color in today's motor cars has set the stage for many new and different metallic finishes. Will we be able to use electronic means to

Acts to Aid Meetings, Publications

cial publication, and other publications. In practice, the Committee will make recommendations to the appropriate Activity Committees for presentation of papers at technical sessions.

"In addition, special reports to the Society will be channeled into publications through the regular Publication Committee policies and procedures. In this connection, a start was made in the January 1957 SAE Journal where in a column under the heading 'SAE Looks Overseas' Hugh Harvey of Shell Oil Co. reported on aircraft plants recently visited by him in England, France, and Germany. In February, Paul Miller of Ford Motor Co. reported on tooling manufacturing methods which he observed on a recent visit to the European Continent. It is hoped that this column may become a regular feature of SAE Journal.

"A number of papers have also been suggested to and scheduled by appropriate Activity Committees for coming National Meetings. . . .

"The Committee is still at work to develop a full working policy which can provide a growing effort in usefulness and in service to the membership of SAE.

"By this means it hopes to inject into SAE meetings and publications an even greater volume of thinking and challenging developments from abroad."

color materials such as steel? This is one of several possibilities discussed by the Committee.

The group agreed that one of the outstanding recent developments was acrylic resin finishes. Resistance to weathering is one of the outstanding characteristics of these new finishes.

Weight Problems Still Plague Truck Engineers

TRUCK and bus engineers are concerned as 1957 begins with a variety of special problems. Among the more important, Truck & Bus Activity Committee discussion indicates, are:

- Weight reduction by design and materials.
- Drives and suspensions for tractors and trailers.
- Interrelation of power steering, power braking, and weight distribution.
- Improvement of truck ride qualities.
- Drives and suspensions for tractors and trailers.

Present and proposed legislation, truck and bus men say, is complicating the interrelation of power steering, power braking, and weight distribution. For better coordination, they are urging that truck and trailer engineers work more closely together on braking problems. Fuller utilization of the safety features of power steering is also being urged, as is more attention to retarding means.

A T & B Activity Committee subcommittee is currently exploring the possibilities of getting weight reduction through designs and materials selected for that purpose. The subcommittee will report on both theoretical possibilities and on specific examples of achievements already made. Chairman of this subcommittee is H. O. Flynn. Serving with Flynn are C. A. Lindblom, V. C. Speece, and R. C. Wallace.

Placement Committee Acts on Bulletin Forms

SAE PLACEMENT Committee is continuing its effort to reduce the current overwhelming bulk of the "Positions Available" bulletins which are a regular part of the Society's Placement Service efforts. Some modification of current bulk, the Committee believes, will improve the actual service rendered by these bulletins both to SAE members and to companies seeking engineers.

With respect to "Men Available," the Committee decided at its last meeting to send out one bulletin each month instead of two, but to designate in an appropriate manner the new listings not in the previous bulletin. Practice of listing each man available for three months and then skipping two months before a relisting will be continued.

The Committee plans to advertise in SAE Journal from time to time the availability of the SAE Placement Service with a brief description of its procedures.

SAE National Meetings . . .

1957

March 20-22
Production Meeting and Forum
Hotel Statler, Buffalo, N. Y.

April 2-5
Aeronautic Meeting
Aeronautic Production Forum
and Aircraft Engineering Display
Hotel Commodore, New York, N. Y.

June 2-7
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 12-15
West Coast Meeting
Olympic Hotel, Seattle, Wash.

September 9-12
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

September 30-October 5
Aeronautic Meeting,
Aircraft Production Forum,
and Aircraft Engineering Display
Ambassador, Los Angeles, Calif.

November 4-6
Transportation Meeting
Hotel Statler, Cleveland, Ohio

November 5-6
Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 6-8
Fuels and Lubricants Meeting
Hotel Statler, Cleveland, Ohio

1958

January 13-17
Annual Meeting and Engineering Display
The Sheraton-Cadillac and Statler Hotels
Detroit, Mich.

Eight New Members of 1957 Technical Board

THE 1957 chairman and eight new members of the Technical Board are as follows.

A. E. W. Johnson, Vice President of International Harvester Co., will serve as chairman of the 1957 Technical Board. In 1916, Mr. Johnson began his present association with International Harvester as a draftsman at the McCormick Works. He became design engineer for harvester-threshers in 1922, and in 1926, was named chief engineer of the McCormick Works Product Engineering Department. A year later he became assistant to the manager of implement engineering in the Company's General Office. In 1941 when farm implement production assumed increased importance, he became manager of implement engineering. When the Harvester Company adopted the divisional form of organization in 1944, Mr. Johnson became manager of engineering for the Farm Implement Division. He served in that capacity until 1947 when he was appointed director of engineering for the Company. In 1952, Mr. Johnson was elected vice president of the International Harvester Company.

A. P. Fontaine, Vice President and Director of Engineering, Bendix Aviation Corp. Following his graduation from the engineering school of New York University, Mr. Fontaine became an aircraft designer for the Fairchild Aircraft Corp. Later, he moved to

Chairman A. E. W. Johnson

A. P. Fontaine

R. H. Isbrandt

M. J. Kittler

W. M. May

R. W. Rummel

E. C. Smith

E. C. Wells

A. E. Williams

The 1957 SAE Handbook . . .

. . . scheduled for publication after June 15, will be the last Handbook published until January 1959.

The change in date of publication is designed to make the Handbook correspond to the calendar year and to permit technical committee members an October thru May work period, uninterrupted by summer vacations. The new January publication date will shift the final approval of projects to be included in the Handbook to the June Technical Board meeting.

Other reasons for favoring the change include:

(1) The change would have the effect of advancing publication date of approved reports.

(2) Issuance shortly after annual dues payment will tend to increase members appreciation of the services offered by the Society.

The unanimous agreement of Technical Committee Chairmen to use the 1957 Handbook for 18 months during the change-over was reported by C. F. Arnold, Chairman of the Publication Policy Committee.

Republic Aviation Corp. as a fighter plane project engineer, and in 1939, joined the Stinson Division of Consolidated Vultee Aircraft. At Convair where he served as assistant director of engineering, Fontaine designed the first successful military liaison-type plane. He joined Bendix in 1944 and remained until 1946, when he took over the direction of the Aeronautical Research Center of the University of Michigan. In 1951, Mr. Fontaine was named vice president and general manager of Convair, where he worked until rejoining Bendix in 1952.

R. H. Isbrandt, Director of Automotive Engineereing at American Motors Corp. Mr. Isbrandt began his career as a chassis detailer with the A. O. Smith Corp. In 1929, he joined Nash Motors as chassis designer and left the firm in 1936 to join Firestone Tire & Rubber Co. as assistant automotive research engineer, assigned to special development work in aircraft and motor vehicle suspension systems. Later he became vice president and general manager of Firestone Aircraft Co. Mr. Isbrandt joined Kaiser-Frazer Corp. in 1947 as chief chassis engineer, and in 1949 became the company's chief aircraft engineer. He rejoined Nash in 1953, and since has served as chief design and executive engineer of both Nash and American Motors. He attained his present position in 1956 as director of automotive engineering at American Motors.

M. J. Kittler, Executive Vice President, Holley Carburetor Co. Mr. Kittler received a BS degree in Mechanical Engineering from the Armour Institute of Technology in 1929. Soon after, Mr. Kittler joined the International Harvester Co. where he did test work on tractor and truck engines and carburetors. At Bendix-Stromberg Carburetor Co., he worked on experimental and development projects on all types of carburetors and on the development of the automatic choke. In 1935, Mr. Kittler joined the Chandler-Groves Division of the Holley Carburetor Co. and since then has devoted much time to the design and development of aircraft carburetors.

W. M. May, Vice President—Engineering, Mack Trucks, Inc. A graduate of M.I.T., Mr. May joined the Mack Company in 1939 as a test engineer. His subsequent activities included working in the design, experimental and research sections of the Engineering Division. He became chief engineer at Mack in 1954 and was elected vice president—engineering in January. Currently, Mr. May is in charge of all engineering activities for Mack Trucks, Inc.

E. C. Smith, Chief Metallurgist and Director of Research, Republic Steel Corp. After graduating from Ohio State University in 1913, Mr. Smith returned to do graduate work in Mineralogy and Metallography. He joined the Gary Works of the U. S. Steel Corp., then enrolled for further study at Columbia University. Later, he became an instructor at Ohio State University in the Engineering School program. After World War I, Mr. Smith became chief inspector at Central Steel, and later, became mill metallurgist. He was named assistant district manager of Republic's Central Alloy District following the merging of Central Steel and United Alloy Steel. Mr. Smith has been chief metallurgist at Republic Steel since 1932. In 1956, he was appointed director of research.

R. W. Rummel, Vice President of Engineering, Trans World Airlines, Inc. Mr. Rummel graduated from the Curtiss-Wright Techncial Institute of Aeronautics. Before joining TWA, he was chief engineer of Rearwin Aircraft and Engines, Inc. Mr. Rummel was simultaneously chief engineer of the Ken Royce Aircraft Engine Co. which

Subcommittee Visits River Works

Following a meeting of SAE's Subcommittee for Standardization of Aircraft Engine Accessory Drive Bearings, members visited the Small Aircraft Engine Department facilities of the River Works. The meeting was held in Boston last December. Seated from left to right are: E. D. Schneider; Chairman D. McLeod, Naval Air Material Center, Philadelphia; V. M. Zwicker; F. G. Mikel, Bureau of Aeronautics; Dr. E. G. Jackson, SAED Thomson Lab; A. W. Dickens of Evendale; L. B. Evans; G. A. Zimmerman. Standing are G. B. Hanson, SAED Marketing, and C. L. Hamm, committee member representing the Small Aircraft Engine Department.

was later merged with the parent company. While associated with these companies, Rummel was responsible for the design and development of light airplanes and aircraft engine models.

E. C. Wells, Vice President—Engineering at Boeing Airplane Co. After graduating from Stanford University in 1931, Mr. Wells joined Boeing's engineering staff where he made detailed drawings of the tail surfaces of the Model 247 transport. In 1939, he became chief of the Preliminary Design Unit of the Boeing Aircraft Co. Two years later, Wells became assistant engineer in charge of Military Projects. A year later, he was named assistant chief engineer. He became chief engineer in 1943.

A. E. Williams, Executive Vice President—Manufacturing and Engineering, Fruehauf Trailer Co. Currently, Mr. Williams is responsible for co-ordinating all engineering and manufacturing efforts at Fruehauf. He has spent considerable time increasing facilities and personnel in the Experimental and Research Departments at Fruehauf. Mr. Williams was recently elected a director of the Truck Trailer Manufacturers Association.

Remaining on the Technical Board are the following members whose terms expire in 1957.

- L. L. Bower—Waukesha Motor Co.
- A. T. Colwell—Thompson Products, Inc.
- R. F. Kohr—Ford Motor Co.
- A. G. Loofbourrow—Chrysler Corp.
- E. F. Norelius—Construction Engineer
- A. E. Smith—Pratt and Whitney Aircraft Division, United Aircraft Corp.

Members whose Technical Board terms end in 1958 are:

- C. F. Arnold—Cadillac Motor Car Division, General Motors
- Trevor Davidson—Bucyrus-Erie Co.
- W. H. Holaday—Dept. of Defense, Office of Assistant Secretary of Defense
- C. L. Sadler—Sundstrands Aviation Division, Sundstrands Machine and Tool Co.
- D. D. Streid—General Electric Co.

1957 Technical Board Chairman Johnson has selected for the Executive Committee the following Board members:

- C. F. Arnold
- A. T. Colwell
- R. F. Kohr
- A. G. Loofbourrow
- C. L. Sadler

The five men, whose three-year terms on the Technical Board just ended, are:

- B. F. Bachman—White Motor Co.
- O. A. Brouer—Swift and Co.
- F. W. Fink—Ryan Aeronautical Co.
- W. C. Lawrence—American Airlines, Inc.
- Harold Nutt—Borg and Beck Division, Borg-Warner Corp.

Technishorts . . .

4000 SAE members have been asked by the Technical Board's Publications Policy Committee to present their ideas about how technical committee information can best be presented for use by SAE members. The Committee is currently studying the replies to its recent survey undertaken to determine the usage and cross reference value of different sections of the Handbook. Some of the responses will also help the committee to determine the need for Special Publications to supplement the Handbook.

Three men were appointed by the Technical Board to serve as SAE representatives on four sectional committees recently organized by ASA's Nuclear Standards Board. The SAE Nuclear Energy Advisory Committee recommended that SAE be represented on these committees. The following were appointed:

DR. ALBERT VAN RENNEN of Bendix Aviation Corp.'s Research Laboratories to Sectional Committee N-3 Nuclear Instruments.
H. J. OGORZALY of Esso Research and Engineering Co. to Sectional Committee N-5 Mechanical Engineering for the Nuclear Field.
DR. H. J. GOMBERG of the University of Michigan, currently in charge of the Michigan Phoenix reactor to Sectional Committee N-6 Reactors Hazards and N-7 Radiation Protection.

The SAE Truck and Bus Technical Committee is setting up a special subcommittee to determine the feasibility of developing a meaningful SAE engineering report on Maximum Gross Vehicle Weight Ratings. This project is being undertaken at the request of the Automobile Manufacturers Association.

The names of two SAE technical committees have been changed from:

1. Passenger Car Body Engineering Committee to **Body Engineering Committee** (with the provision that the Committee, when dealing with problems and projects affecting commercial vehicles, coordinate its work with the SAE Truck and Bus Technical Committee).
2. Hydrodynamic Drive and Transmission Committee to **Transmission Committee.**

SAE's Aircraft Electrical Equipment Panel has undertaken work to coordinate requirements for electrical equipment to counter-act detrimental effects of radiation.

The new Relays group of the Aeronautics Accessory and Equipment Division has started work on contact contamination standardization. Its work will be coordinated with the military on revisions of current relay specifications, the American Institute of Electrical Engineers task group on inductive loads, and the Aircraft Industries Association-Electronic Equipment Committee Relay Panel covering relays for electronic usage.

The death of Harry R. Wolf was announced at the January 17 Fuels and Lubricants Technical Committee meeting. In commemoration of his friendship and many services to the Society, a resolution expressing the committee's condolences to Mr. Wolf's family and its gratitude for his help in furthering technical committee work was passed. For years a member of the Fuels and Lubricants Technical Committee, Mr. Wolf was also active on the Torque Converter Fluids Subcommittee and Subcommittee A—Transmission and Rear Axle Lubrications and Engine Coolants Subcommittee of the Non-Metallic Materials Committee.

Reducing Shock and Vibration Interference . . .

. . . with normal operation of an airplane's electronic equipment by application of easy-to-understand ground rules for designing is aim of first studies by new SAE technical committee. Good start already made.

A RECENTLY formed SAE technical committee has made a start toward giving design engineers easy-to-understand and easy-to-apply ground rules for designing so that shock and vibration will not interfere with the normal operation of an airplane's electronic equipment. Designated as S-12, this SAE Committee for Shock and Vibration has already:

1. Completed some of the studies on one-degree and six-degree of freedom systems employed for steady-state vibration isolation as well as some studies on response of isolation systems to random excitation;
2. Issued several technical documents to Committee members on these subjects; and
3. Detailed a program for study of certain fundamental dynamical systems . . . and determined to examine the pertinent non-dynamical characteristics of these systems later.

Chairman of S-12 is Lockheed's Dr. C. T. Molloy, who started operations by contacting top level engineering management of West Coast aircraft firms to pin-point shock and vibration problems of mutual concern. The investigation of the problem of isolation of electronic equipment from shock and vibration was decided upon as the Committee's first project. Others will be undertaken later.

The Committee is pursuing its program actively through four subcommittees . . . on sources, on isolation systems, on receivers, and on random excitation. THE SUBCOMMITTEE ON SOURCES will study vibration, shock and acoustic sources which exist on aircraft. It will later propose means of describing these sources in terms of significant parameters. Also, it will propose techniques to measure these parameters.

The parameters chosen for description will be such as to permit determination of the motion of the receiver of the vibrational energy, when the isolation system parameters and the receiver parameters are also given.

THE SUBCOMMITTEE ON ISOLATION SYSTEMS will study systems whose function is to provide isolation from vibration, shock, and acoustic excitation. This group will propose means of describing isolation systems which, taken together with the source and receiver parameters, will permit determination of the motion of the receiver. Also, it will propose means of measuring the quantities selected for description of the isolation systems.

THE SUBCOMMITTEE ON RECEIVERS (items which are recipients of vibrational, shock, or acoustical excitation), will study the parameters necessary to describe the motion of the electronic equipment when it is coupled to a vibration, shock, or acoustical source through an isolation system. It will also:

a. Propose means for measuring these parameters, and

b. Propose criteria in terms of the parameters used for describing the motion of the equipment, which define the amount of motion the equipment can safely withstand.

THE SUBCOMMITTEE ON RANDOM EXCITATION will study the response of mechanical systems to such excitation and propose to the other three subcommittees any suggestions resulting from this study that appear applicable to the work of these other groups.

The program detailed for study of the one-degree and six-degree of freedom dynamical systems is aimed to give the isolation-system designer:

1. The various parameters which are required to define the performance of the system which he is designing;

2. How to use these parameters to achieve a satisfactory design;

3. Suggested methods by which these parameters can be measured.

The program as outlined follows:

1. Steady state vibration problem.
   a. One-degree of freedom systems.
   b. Six-degree of freedom systems.
2. Shock isolation problem.
   a. One-degree of freedom systems.
   b. Six-degree of freedom systems.
3. Response to random excitation.
   a. One-degree of freedom systems.
   b. Six-degree of freedom systems.
4. Detailed study of vibration sources on aircraft.
   a. Optimum choice of parameters describing the sources.
   b. Procedures for measuring the selected parameters.
   c. Compilation of numerical values of parameters which are presently available.
5. Detailed study of receivers (electronic equipment) on aircraft.
   a. Optimum choice of parameters for describing the dynamical characteristics of the receiver.
   b. The means for measuring the optimum parameters selected.
   c. Method of specifying the fragility of the receiver (e.g. the amplitude of the sinusoidal displacement which the equipment can

safely withstand, plotted as a function of frequency over a given frequency band or the maximum acceleration and the duration of that acceleration which the equipment can safely withstand.)

6. Detailed study of isolation systems.

   a. The specification of the optimum parameters for describing the isolation system.
   b. Methods for measuring these parameters.
   c. Compilation of numerical values of these parameters which are presently available.
   d. Development of design techniques which combine the given dynamical parameters in such a way as to define the optimum parameters for the isolation system.

Detailed Study

Detailed study of other than dynamical characteristics of vibration isolators which must be considered.

1. Pertinent dimensions; standardization of drawings showing all important dimensions and isolator essentials.

2. Environment; effects of temperature, aging, setting, etc.

3. Endurance; adequate method for specifying endurance characteristics of isolators and method of measuring same.

4. Structural strength; method of adequately specifying structural strength of isolators and method of measuring same.

5. Other miscellaneous items.

Committee Is Representative

The Committee, as organized under Chairman Molloy's leadership, consists of active members and consultants. Both active members and consultants are engineers who have had considerable experience in various phases of the electronics equipment mounting problem. The active members are those who are so located as to be able to attend monthly committee meetings.

The present roster of the Committee is as follows:

ACTIVE MEMBERS: Committee Officers: Dr. C. T. Molloy, Lockheed, chairman; Dr. C. T. Morrow, Ramo Wooldridge Corp., vice-chairman; F. Mintz, Lockheed, secretary.

Subcommittee on Sources: W. W. Harter, Northrop, chairman; G. L. Getline, Convair; F. P. Klein, Hughes Aircraft; F. Mintz, Lockheed; C. L. Walker, Jr., Douglas; R. R. Beachler, North American; Dr. S. Rubin, Lockheed.

Subcommittee on Isolation Systems: E. Raymund, E. V. Roberts and Associates, chairman; V. Benson, E. V. Roberts and Associates; L. Foglesong, Barry Controls; C. P. Haber, Lord Manufacturing; H. Jencks, Douglas; J. B. Hartley, Lord Manufacturing; H. Himelblau, North American; G. H. Klein, Robinson Aviation.

Subcommittee on Receivers: F. B. Safford, Northrop, acting chairman; R. A. Blais, Gilfillan Brothers; H. Himelblau, North American; J. McAnulty, Bendix Aviation; Dr. J. T. Muller, New Jersey Dynamic Testing Laboratories; G. W. Schatz, Hughes Aircraft; K. Kuoppamaki, Naval Ordnance Laboratory; E. Lahnala, Collins Radio Company.

Subcommittee on Random Excitation: Dr. C. T. Morrow, Ramo Wooldridge Corp., chairman; Dr. R. S. Bradford, Jet Propulsion Laboratory; A. J. Curtis, Hughes Aircraft; L. Foglesong, Barry Controls; G. L. Getline, Convair; F. Mintz, Lockheed.

Consultants

Consultants: L. Batchelder, Raytheon Manufacturing; W. T. Carnes, Aeronautical Radio, Inc.; F. Cooper, Northrop Aircraft; C. E. Crede, Barry Controls; H. C. Dalyrmple, U.S. Naval Engineering Experiment Station; C. Davis, Robinson Aviation; Dr. H. R. Friedrich, Convair; C. Golueke, Wright-Patterson Air Force Base; W. Hall, RCA Service Company; M. Harrison, David Taylor Model Basin; D. C. Kennard, Wright-Patterson Air Force Base; Dr. E. H. Kennard, David Taylor Model Basin, Dr. E. Klein, Naval Research Laboratory, W. Luebking, Collins Radio Co.; C. W. McDowell, Wright-Patterson Air Force Base; R. T. McGoldrick, David Taylor Model Basin; H. McGrath, Wright-Patterson Air Force Base; Dr. H. O. Parrack, Wright-Patterson Air Force Base; S. Pines, Republic Aviation; J. Rebman, Lord Manufacturing; Dr. O. R. Rogers, Wright-Patterson Air Force Base; J. Tyler, Pratt and Whitney Corporation; K. Unholtz, MB Manufacturing; Dr. I. Vigness, Naval Research Laboratory.

SAE Committee S-12, Aircraft Shock and Vibration

Rear row, left to right: C. L. Walker, R. S. Bradford, C. P. Haber, G. L. Getline, G. W. Schatz, H. Himelbiau, H. Jencks, J. B. Hartley, S. Rubin, L. Foglesong, A. J. Curtis, R. R. Beachler, C. T. Luce, K. Kuoppamaki. Front row, left to right: F. Safford, E. C. Raymund, F. Mintz, C. T. Molloy, C. T. Morrow, W. W. Harter, E. W. Rentz, C. H. Klein.

11 New TC Chairmen Elected; 12 Reelected For 1957

ELEVEN technical committee chairmen were elected and twelve were reelected, it was announced at the January 17 Technical Board Meeting in Detroit.

The eleven new chairmen are:

P. G. BELITSOS of General Electric Co. — Aeronautical-Automotive Drawing Standards Committee
L. A. CUMMINS of Marlin-Rockwell Corp.—Ball and Roller Bearings Committee
R. L. DOUGLAS of Eastern Motor Express, Inc.—Transportation and Maintenance Technical Committee
R. W. HAUTZENROEDER of Massey-Harris-Ferguson, Inc.—Tractor Technical Committee
V. E. HENSE of Buick Motor Division, General Motors Corp.—Iron and Steel Technical Committee
R. F. HOLMES of AC Spark Plug Division, General Motors Corp.—Screw Threads Committee
J. T. O'REILLY of Ford Motor Company—Nonmetallic Materials Committee.
V. J. ROPER of General Electric Co.—Lighting Committee
P. J. SPERRY of International Harvester Co.—Construction and Industrial Machinery Technical Committee
H. D. WILSON of Ford Motor Co.—Electrical Equipment Committee
C. M. WRIGHT of Chrysler Corp.—Automotive Drafting Standards Committee

The twelve reelected chairmen are:

E. L. ALLEN of Schonitzer Engineering Co.—Passenger Car Body Engineering Committee
A. C. BODEAU of Ford Motor Co.—Riding Comfort Research Committee
C. M. DEAN of Pratt and Whitney Aircraft—Ignition Research Committee
J. GURSKI of Ford Motor Co.—Nonferrous Metals Committee
A. L. HAYNES of Ford Motor Co.—Motor Vehicle Seat Belt Committee
C. M. HEINEN of Chrysler Corp.—Fuels and Lubricants Technical Committee
O. K. KELLEY of General Motors Corp.—Transmission Committee
L. C. KIBBEE of American Trucking Associations, Inc. — Truck and Bus Technical Committee
C. E. MINES of the Allison Division of General Motors Corp. — Aeronautics Committee
G. A. REA of Heil Company—Tube, Pipe, Hose and Lubrication Fittings Committee
R. K. SUPER of Rockwell Spring and Axle Co.—Brake Committee
R. P. TROWBRIDGE of General Motors Corp.—Parts and Fittings Committee

Cockpit Committee Retains Standard

SAE's Cockpit Standardization Committee has found no outstanding basis for adopting a change from the "basic six" to the "T" formation proposed by the Air Line Pilots Association. After extensive re-examination of its present standard, described in SAE's Aeronautical Standard, Cockpit Flight Instrument Panel Arrangement, the Committee has made the following recommendations:

1. The present standard instrument panel be retained until a scientific basis for change is developed by adequate eye motion studies or by other unbiased research.

2. The Committee suggests that because of the importance of a basically good standard flight instrument panel in time of peace and war, government funds be made available for research on this problem. (The Committee has offered its technical assistance on any such project.)

3. The Committee feels that if the government decides that a national standard is necessary, such a standard should be made applicable to all transport operators including the civil and military.

Engine Testing Panel Created

A NEW Engine Testing Study Panel, created by the Engine Division of the Aeronautics Committee, will determine if it is feasible to establish a uniform engine test code or recommended practice. Its objective will be to enable the aircraft industry and military services to determine the true performance of turbojets.

Problems have arisen when trying to duplicate test stand results for turbojets, J. D. Clark of the Department of Navy, Bureau of Aeronautics, reports. In spite of taking every known precaution, there have been discrepancies by as much as five percent on test data accumulated on test stands. Difficulties have been encountered when trying to duplicate engine calibration previously established by the engine manufacturer, or when trying to obtain data correlations from brand new engines sent to different testing laboratories. Results in such cases have shown an inability to duplicate test data accurately.

Some of the variables to be studied by the Panel will include mass air flow, test cell depression, and critical distance between the engine and test cell exhaust cone.

Aero Standards, RPs Available

SEVEN new and five revised Aeronautical Standards and Recommended Practices are now available in looseleaf form to supplement those previously issued. They are as follows:

- ARP 218A — Mounting Pads and Drives, Motor Operated Thru Spline-Pinion
- ARP 243A — Nomenclature, Aircraft Hydraulic and Pneumatic Systems
- AS 245A—Water Solution Type Hand Fire Extinguisher
- AS 405A—Fuel and Oil Quantity Instruments
- AS 412A—Carbon Monoxide Detector Instruments
- AS 418 — Maximum Allowable Airspeed Indicators
- AS 452—Oxygen Masks for Non-Military Airplanes
- AS 463—Oxygen Regulators For Commercial Transport Aircraft
- ARP 494 Terminals—Input and Output—Ignition Exciters
- ARP 503—Emergency Illumination
- ARP 570—Designation of Direction of Rotation of Helicopter Rotors
- ARP 571—Instrumentation and Cockpit Control Arrangement for Electronic Navigation and Communication Aids.

(The above, plus new Numerical and Alphabetical Indexes for all Aeronautical Standards and Recommended Practices may be obtained at a minimum charge of $2.75.)

SECTIONS

MARCH 1957

Managements Evaluate Technical Society Membership

"If management is to get what it expects from its technical people, it must recognize the overall contribution which comes to the company through the broadening experience of its employees within the technical society," declared G. E. Burks, Caterpillar Tractor Co.'s vice-president for engineering, at the SAE Membership Committee meeting held in January.

Enlarging on the idea of company awareness of professional society importance were J. E. Yingst, manager, staff research and development, Thompson Products, Inc.; D. D. Streid, manager, engineering jet engine department, Aircraft Gas Turbine Division, General Electric Co.; and P. H. Pretz, executive engineer, vehicles test office, Ford Motor Co.

In setting the pace for the meeting, Burks emphasized the fact that management utilizes the mental generating power of those employees who have acquired a broad-gage background of knowledge in many technical fields. This knowledge, he pointed out, is best secured by active participation in technical societies.

As a concrete example of the value which companies place on technical society membership, Burks noted that his firm pays the dues of those employees whom the company believes would be more valuable in their jobs if they were active society members. It goes half way in meeting the dues of other employees who affiliate with technical societies on their own. This company backing is made as an indication of its approval of technical societies rather than on an employees' financial need basis.

Meeting Attendance

Discussing management attitude toward employee participation in technical society meeting, Yingst said that professional societies and their activities have the whole-hearted support of top management at Thompson Products.

Based upon the belief that no individual or company gets more from an activity, endeavor, or professional society, than he puts into it, Yingst revealed that Thompson Products, as a company, encourages attendance at Section and National Meetings of SAE, as well as participation on committees.

Yingst stated further that his company is convinced that by such participation, the engineers and the company benefit through:

- Learning who is doing what in other companies
- Obtaining information through meetings and informal associations
- Allowing others the opportunity to know the company and its engineers
- Keeping the name of the company active

Thompson Products policy toward meetings, Yingst added, is firstly to encourage attendance at Section meetings, but not to underwrite the cost of attending these sessions, and secondly, to encourage, with discretion, attendance at National Meetings, and to subsidize the necessary expenditures as a business expense.

It is the company's feeling he explained, that attendance at Section meetings is compatible with the employee's ability to pay—and that his willingness to pay is indicative of his interest.

In the case of out-of-town National Meetings, attendance requires travel and other expenses of some magnitude; often company business matters are discussed; opportunities are provided for broad contacts which are to the company's advantage, and control of attendance contributes to maximum benefit to employees and company. On the control of attendance, Yingst, said, this is covered first by budget appropriations and second by responsibility given department managers to select personnel to attend National Meetings.

Committee Membership

Management attitude toward employee membership on technical and administrative committees was Streid's topic for discussion.

continued on page 90

An Option . . .

"Any member residing outside Section territory, upon written request for assignment to membership in a given Section may be so assigned.

"Such a member can select only one Section."

The above information (pertinent to about 5% of SAE members who live outside Section or Group territory) is printed at the request of SAE Council.

Request for assignment to a specific Section or Group should be addressed to Sections Department at SAE Headquarters.

Continued from page 89

Opening his remarks with the statement that General Electric pays employee dues for technical society membership, providing the employee personally pays his dues in one "founder society," Streid explained that his company assumes expenses for attendance at a national meeting, but does not pay for attendance at a local meeting of a technical society.

General Electric, Streid said, considers participation in technical activities a part of an engineer's job.

Streid reasons along this line: "We get assistance on work related to technical committee activities. I refer all technical problems to standards engineering, materials laboratory, the specifications engineer and the legal department." All of these people, he added, consider it part of their jobs to cooperate in assignments growing from technical committee activities.

The General Electric management, Streid summarized, encourages reasonable participation in technical and administrative committees of technical societies by:

- paying expenses
- giving help (technical and clerical) plus a fraction of a man's time
- arranging for suitable representation on committees
- recognizing this as a part of a man's job and measuring his contributions accordingly
- encouraging participation of outstanding men

The job you do on a professional society assignment, Streid added, shares weight with company assignments when consideration is given to merit increases.

The question of management's attitude toward invitations to present technical papers was answered by P. H. Pretz.

The Ford Motor Co. is in favor of qualified employees participating in the presentation and discussion of technical papers at SAE meetings, Pretz told his listeners. Generous allotments of time are granted for the preparation of these technical papers. In some cases, he added, this presentation might include purchase of materials, investigations, studies, and the running of many tests. In other instances, the use of information and data of somewhat restricted nature is presented. In all cases, the costs of manuscripts, slides, and occasional exhibits are paid by the company.

Often, Pretz stated, individual employees are asked to be speakers or to participate in some Society sponsored activity. It is the Ford policy, he said, to provide the most qualified employee for the occasion. This may turn out to be an employee other than the one requested. This should not be surprising, he said, in such a large organization with specialists in many technical areas.

Of course, Pretz added, the travel expenses of the employees selected to present papers are borne by the company.

In concluding, Pretz explained to the group the necessity that all technical papers for presentation to, or publication by, any technical society, must be reviewed before release. This is required, he said, for security reasons; also to avoid involvement in a patent situation or premature disclosure of confidential material.

Nominating Committees Operating at Top Speed

Reports of the Sections' Nominating Committees for 1957–1958 have reached headquarters at a faster rate this year than in any previous year.

This is an indication that the various Nominating Committees, which were elected in January and February of this year, have been operating at full speed.

Following customary procedure, each Section's (or Group's) Nominating Committee has a three-fold assignment.

The first step is to nominate one candidate for each of the Section's elective offices, which are: chairman, vice-chairman, secretary, and treasurer. It must also nominate regional and/or Activity vice-chairmen for which the Section has received Council authorization.

The next step is to nominate one candidate, who must be a voting member of the Society, to represent the Section as a delegate to the Society's 1958 Nominating Committee. In addition, they nominate two alternates, who must also hold member grade.

The final nomination made by the Committee is of a candidate to represent the Section on the SAE Sections Committee during 1958.

When these actions have been completed, the Section Nominating Committee presents its proposed slate of officers to the Section Governing Board, which in turn presents the slate at a Section meeting.

Ballots are mailed to Section members in good standing thirty or more days before the last scheduled meeting of the Section year.

Sections Add Vice Chairmen

THE CANADIAN SECTION has changed the designation of its "Vice-Chairman representing Sarnia" to "Vice-Chairman representing London-Sarnia Region."

THE MID-CONTINENT SECTION will add to its elective offices an Activity Vice-Chairman representing Fuels & Lubricants.

THE ALBERTA GROUP will add a Regional Vice-Chairman representing Edmonton to its elective offices.

So. California

W. E. Achor, Field Editor

Coffee Speaker Popular in So. Cal.

The Southern California Section is continuing the custom started last year of having a ten minute coffee talk as part of the regular dinner meetings. The talk is given following the dessert and just prior to a ten minute intermission preceding the evening's paper.

Luigi Lesovsky, of the Lesovsky Race Car Engineering Co., is this year's appointed coffee speaker chairman. It is his responsibility to bring a few choice words to the dinner meeting audience concerning developments in the racing picture. This talk, either specific or general, may involve boats, stock cars, racing cars, or airplanes.

It is the coffee speaker chairman's prerogative either to secure a guest coffee speaker or give the coffee talk himself.

As an example, at the Section's Jan. 14 meeting, the coffee speaker chairman talked about stock car competition and the contributions these races make to the improvement of the stock passenger cars.

Southern California Section held a Fuels and Lubricants Symposium on Jan. 28–29 with **J. Brent Malin**, technical representative, Petroleum Chem-

icals Division, E. I. DuPont de Nemours & Co. serving as moderator.

The five-paper program included: "The Availability of Jet Fuels" by **Allen E. Smith,** chief aviation engineer, Socony-Mobil Oil Co.; "What Fuel Characteristics Mean to the Turbine Engine Airplane" by **Carl Weiss,** powerplant section chief, Douglas Aircraft Co.; "Restrictive Specification Will Increase Jet Fuel Cost" by **Harold R. Porter,** senior product engineer, Standard Oil Co. of California; "Problems That Can Be Helped by Better Fuels and Lubes" by **G. R. Wynne,** police transportation superintendent, City of Los Angeles; and "The Partnership of Engineering and Petroleum" by **John A. Edgar,** chief research engineer, Shell Oil Co.

Principals of the Cleveland Section January 21 meeting are left to right: speaker's sponsor T. R. Thoren; guest speaker C. H. Nystrom of American Bosch Arma Corp., who spoke on "Fuel Injection for Automobiles"; and Cleveland Section Chairman A. D. Gilchrist.

CLEVELAND

W. B. Fiske, Field Editor

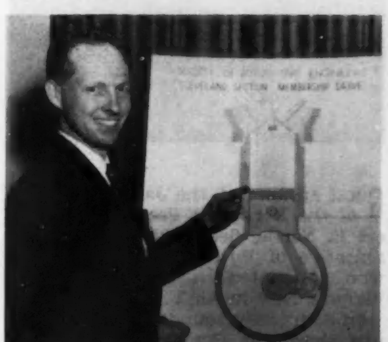
Display Sparks Membership Drive

Membership Chairman **J. R. Doyle** and assistant Membership Chairman **H. F. Hostetler** are using a unique idea to apprise the members of the Cleveland Section as to the progress being made in the membership growth.

At each meeting, a special display is set up in the form of a single-cylinder engine with adjustable cylinder. The level of the cylinder, with figures at the side, indicates the progress being made toward the year's goal of 180 new members. The animated engine sketch is set up near the ticket desk where all those attending the monthly meeting will see it.

In addition, Chairman Doyle, in his monthly report in the SAE Junior Journal, uses the engine drawing as a visual aid to getting his membership story across.

Prior to the meeting, members inspected a fuel injection system on an automobile. The car, on display in the hotel basement, gave members and guests a chance to inspect the fuel injection system before and after it was discussed at the meeting.



J. R. Doyle, Membership chairman of the Cleveland Section points with pride to the engine sketch display he uses to show the Section's membership growth.

In a huddle before the meeting are left to right; J. Howard Dunn, Cleveland Section treasurer; Lawrence Pomeroy, technical editor of The Motor, London, England; and Cleveland Section Secretary Edwin H. Scott.

From Section Cameras

1. Featured speaker **C. O. Slemmons** (left), chief product development engineer, General Tire and Rubber Co., is greeted by Program Chairman **William Moranda** (right) at the Feb. 5 meeting of the **Northern California Section's South Bay Division.** Subject for the evening was "Compressed Air Springs."

2. Members of the **Texas Gulf Coast Section** gather with the honored guest at the Section's January production activity meeting. Standing left to right are: **William Tilden,** Section secretary; **O. H. Stelter,** Section Meetings chairman; guest speaker **Lloyd J. Wolf,** of Wolf Engineering Co., Dallas, Texas; and **Louis F. Mock, Jr.,** Section chairman.

3. Discussion at the meeting centered around the activities and products of the Wolf Engineering Co. which manufactures unusual transportation equipment.

Shown here standing beside the Wolf Wagon or self-propelled van are Texas Gulf Coast Section members **George Lewis, Frank Denny, Leon Blagg, Frank Wilson,** and **Edward Asch.**

4. Principals of the **Central Illinois Section** Dec. 17 meeting gathered for this Journal photograph. Left to right are: guest speakers **Edgar S. Cheaney,** Allis-Chalmers Mfg. Co.; **C. R. Brant,** Caterpillar Tractor Co.; **Donald R. Buerschinger,** LeTourneau-Westinghouse Co.; **E. J. Eckert,** technical chairman for the meeting; **R. D. Henderson,** Section chairman; and speaker **Walter M. McCulla,** Caterpillar Tractor Co.

NORTHWEST

B. H. Murray, Field Editor

Guest speaker at the Jan. 18 meeting of the Northwest Section was **Robert E. Norris,** fleet and special representative of Purolator Products, Inc., who presented a paper entitled, "What's New in Air Filters?"

In addition, a sound and color movie was shown by Cummins Engine Co., illustrating the terrific damage done to an engine when even small amounts of dust material enters the intake system. This film stressed the points made in the discussion.

Earthmoving Industry Conference Program

TUESDAY, MARCH 26

9:30 AM Welcome by General Chairman—**W. H. McGlade**

Keynote Address—**Bertram D. Tallamy**, Federal Highway Administrator

Technical Chairman—**Ernest W. Spannhake**, LeTourneau-Westinghouse Co.

"The Army's Wheeled Vehicles"
Col. J. J. Wilson, U. S. Army Armor Board

1:30 PM Technical Chairman—**R. P. Van Zandt**, Caterpillar Tractor Co.

"The Beam Strength of Modern Gear Tooth Design"
B. W. Kelley and **R. Pederson**, Research Department, Caterpillar Tractor Co.

"Converters Can Be Different"
James B. Black and **Marvin W. Dundore**, Hydraulic Division, Twin Disc Clutch Co.

6:30 PM Banquet—Toastmaster—**R. D. Henderson**

Speaker—**Edward McFaul**
"So You Think You're Slipping"

WEDNESDAY, MARCH 27

9:00 AM Technical Chairman—**D. W. Erskine**, Allis-Chalmers Mfg. Co.

"Mobile Laboratory Instrumentation"
W. D. Speight and **W. H. Jones**, Research Department, Caterpillar Tractor Co.

"Terrain Evaluation in Automotive Off-the-Road Operation"
M. G. Bekker, Land Locomotion Laboratory, Detroit Arsenal

1:30 PM Technical Chairman—**W. J. O'Shaughnessy**, Hyster Co.

"Development of the New International Payhaulers"
Kenneth Kollinger, Construction Equipment Division, International Harvester Co.

"Power Shift and Move More"
M. Lowell Conrad, Construction Machinery Division, Clark Equipment Co.

"Aluminum in Earthmoving Equipment"
W. C. Weltman, Sales Development Division, Aluminum Company of America

MONTREAL

A. A. Larkin, Field Editor

Student Committee Steps-Up Its Activity

Current activities of Montreal Section's Student Committee reached a new peak of achievement at the January meeting when 40 students attended Students' Night. They mingled with Section members and heard two fellow-students, Gerald McMartin of Montreal University's Ecole Polytechnique, and David Hobart of McGill University, present their prize-winning papers. Awards of $50 and $30 were presented to McMartin and Hobart respectively.

Growth of students' interest in the Montreal Section can be attributed to the carefully planned work of the Section's Student Committee under vice-chairman **B. H. Miller.** To foster still greater interest in SAE, Miller hopes to arrange for visiting speakers to present their papers to specially arranged student-gatherings in university halls on the afternoons of Section meeting dates. It is felt that such presentations would be highly attractive to students and would lead to many more SAE Enrolled Students.

The Section is also considering a plan to get many more regular members out to next year's Students' Night. Foundation of the plan would be to ask each member to take a student to the meeting as his guest, to remain with him for the evening as his host, and to introduce him to many other regular members in the course of the meeting. It is felt that this procedure would assure a highly enjoyable and interesting time to both parties, and encourage many more students to affiliate with SAE and to come out regularly to meetings.

New England

George T. Brown, Field Editor

"You don't supervise a truck fleet with horse and buggy ideas," was the gist of the subject discussed by **Lewis C. Kibbee**, chief automotive engineer, American Trucking Association, at the Section's transportation and maintenance meeting, Jan. 8.

Prior to the technical presentation, **Harry Stanton,** Boston Globe, assumed his customary role of coffee speaker.

From Section Cameras

1. **Twin City Section Treasurer D. L. Van Orman** welcomes to the Jan. 9 meeting guest speaker **S. M. Weckstein,** chief engineer, Industrial Division, Timken Roller Bearing, who spoke on "Design and Lubrication of Anti-Friction Bearings."

The meeting was held jointly with the American Society of Lubrication Engineers.

2. Guest speaker for the **Wichita Section** Dec. 13 meeting was **L. W. Newcomer,** chief engineer for the Kansas Turnpike Authority who gave a talk on the Kansas Turnpike.

3. **South Texas Group** members enjoy a paper on "Vertical Take-Off and Handling Aircraft — Helicopters and Their Powerplants," presented by **R. G. Ervin** (standing), vice-president of Hawk Helicopters, Fort Worth, Texas, at the Jan. 28 meeting.

4. **I. M. Harlow** (right), technical chairman for **Northern California Section** Jan. 23 meeting, joins guest speaker **A. M. Brenneke** (left), chief engineer, Perfect Circle Corp., during the question and answer period which followed the talk on "The Heavy Duty Oil—Slow Run-In Question."

After the discussion period, Raymond Burton, manager, sales promotion, Central Division, General Petroleum Corp., presented the film "Safety Economy Run."

SYRACUSE

D. J. Ritchie, Field Editor

The new year was appropriately welcomed in the Syracuse Section on Jan. 8 with a discussion of the technical highlights of the 1957 cars. **Thomas A. Bissell,** manager, SAE Meetings Division, illustrated his paper, "Trends in 1957 Car Design" with slides which assisted the members in comprehending the numerous changes that have take place in the field.

Philadelphia

E. V. Henc, Field Editor

"Research and Development through Uninhibited Thinking" was the title of the paper presented by **Commander George W. Hoover** of the U. S. Navy, at the Section's joint aircraft meeting with the Institute of the Aeronautical Sciences held Jan. 9.

Commander Hoover illustrated his talk with films and slides on instrument integration for Navy aircraft.

BUFFALO

S. E. Leese, Field Editor

A plant tour and a standing ovation were highlights of the January 8 meeting of the Buffalo Section.

The standing ovation was given by the group to **Burnham E. Field** as he was presented with a plaque commemorating his 35 years with SAE.

Following the dinner meeting, the group made a tour of the Dunlop Rubber Co., Buffalo with the 150 members divided into groups of about 15 members each.

ST. LOUIS

F. H. Myers, Jr., Field Editor

An audience of 250 engineers heard **John S. Coleman**, General Motors Corp. Technical Center, talk on "The Gas Turbine and its Application to Motor Vehicles" at the January 31 meeting of the St. Louis Section which was held in conjunction with the St. Louis Engineers Club. The speaker supported his discussion with a set of colored slides.

Well over 250 people launched the festivities at the St. Louis Section's annual Ladies' Night on Jan. 8.

The fun began with a social hour, followed by a dinner, and rounded out with a play entitled, "He Ain't Done Right by Nell."

The play, which was performed by a group of talented "Y" players, was a "gay nineties" melodrama such as those typical of the old Mississippi River show boat production. Members and their better-halves lustily booed the villain, cheered the hero and offered additional dialogue to the performers.

Three scenes taken at the annual Ladies' Night celebration at the St. Louis Section are shown here.

In the top photo Section Chairman Henry J. Buelt presents a corsage to Mrs. E. S. Kropf, wife of the Section vice chairman.

The middle photo catches a glimpse of the members and guests as the party is well on its way.

The play is the thing in the lower photo. The entire production was staged in the center of the ballroom floor with no scenery, a few chairs, a couple of tables, and a teapot.

SO. TEXAS

N. Killion, Field Editor

Student Night Scheduled for March

March 27 will bring the annual Student Night festivities to the South Texas Group. Students are expected from Trinity University in San Antonio, University of Texas in Austin, Texas Arts and Industries of Kingsville and St. Mary's University in San Antonio.

The program will feature a talk on "The Application of Gas Turbines to Powerplants" by **Dr. C. G. A. Rosen**, SAE past-president, and consulting engineer to the president, Caterpillar Tractor Co., Peoria, Ill.

The day's activities will include tours of the Engines, Fuels and Lubricants, and Aircraft Divisions of Southwest Research Institute.

CANADIAN

F. G. King, Field Editor

Members of the Canadian Section now know what the S.T.O.L. Aeroplane is. A well-attended "Aviation Night" January meeting heard an address by **Russell Bannock**, director of operations, DeHavilland Aircraft of Canada Ltd., on the present and future uses for the "Slow Take Off and Landing Aeroplane." The Beaver and Otter models of DeHavilland were discussed with the aid of colored slides.

PITTSBURGH

H. J. Grance, Jr., Field Editor

A survey of heavy duty fleets conducted periodically by the Ethyl Corp., covering characteristics of commercial engines in over-the-highway operation throughout all parts of the United States, was discussed at the Section's Jan. 22 meeting. Guest speaker for the occasion was **E. L. Tandrup**, engineering service section, technical service department, of the Ethyl Corp.'s Detroit Research Laboratories.

Section Meetings

CENTRAL ILLINOIS

March 26–27 . . . Earthmoving Industry Conferences. Pere Marquette Hotel.

CHICAGO

March 12 . . . **Lee Ohlinger** of Northrop Aircraft.—"Nuclear Power In The World of Tomorrow." Knickerbocker Hotel.

March 18. SOUTH BEND DIVISION . . . **James O'Malley**, Bell Aircraft.—"Design and Testing of UTOL Aircraft for Vertical Take-off and Landing."

CLEVELAND SECTION

March 18 . . . Panel Meeting. "Engineering Department Morale." **Michael Vaccaro**, N.A.C.A. —"Employee's Viewpoint."; **T. Cyril Noon**, Thompson Products, Inc., "Supervisors Viewpoint."; and **Wade White**, Euclid Division, GMC,—"Corporation (Management) Viewpoint." Cleveland Engineering Society Building.

April 6 . . . Annual Dinner-Dance

April 9 . . . Akron-Canton Meeting. **Louis P. Shannon**, Public Relations Department, E. I. du Pont de Nemours & Co.—"Let's Look at Tomorrow." Mayflower Hotel.

METROPOLITAN

March 14 . . . Fuel & Lubricant Dinner Meeting. **C. A. Hall**, research supervisor, Ethyl Corp.—"Spark Plug Fouling." The Brass Rail Restaurant, Fifth Avenue & 43rd Street, New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

March 28 . . . Transportation & Maintenance Activity Meeting. **H. Joseph Chase**, base manager, Lockheed Aircraft Service-International Inc.—"Comparisons between Truck Fleet & Airline Maintenance Service." Belmont Plaza Hotel, Lexington Avenue & 49th Street, New York. Meeting 7:45 p.m.

April 11 . . . Diesel Dinner Meeting. **Arthur F. Underwood**, Head Mech. Dev. Dept., General Motors Research Staff, GMC.—"Free Pistons." The Brass Rail Restaurant, Fifth Avenue & 43rd Street, New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m.

MILWAUKEE

April 5 . . . Milwaukee Athletic Club. Social hour 6:00 p.m. Dinner 6:30 p.m. Meeting 8:00 p.m.

MONTREAL

March 19 . . . **W. Paul Eddy**, 1957 SAE President.—"From Pistons to Jets." Dinner and Meeting, Sheraton Mount Royal Hotel.

PHILADELPHIA

March 13 . . . Transportation & Maintenance Activity Meeting. **John Swift**, International Harvester. — "New Select - O - Matic Transmissions."

April 10 . . . **W. Paul Eddy**, 1957 SAE President.—"From Pistons to Jets."

SYRACUSE

March 12 . . . **E. P. Palmatier**, manager, Transportation Section, Carrier Corp., Syracuse.—"Air-conditioning the DC-8."

April 9 . . . **W. Paul Eddy**, 1957 SAE President.—"From Pistons to Jets."

1956

SAE Journal Index

soon to be available – at No Charge

AN INDEX of all technical articles published in the 1956 issues of the **SAE Journal** will be ready about March 1.

It's **FREE** for the asking. To get your copy, write to: Editor, **SAE Journal,** 485 Lexington Ave., New York City 17.

SAE Journal sooner or later prints an abridgment of every paper presented at SAE National and Section Meetings. So, every paper is mentioned at some time in the INDEX.

Every paper is indexed by:

1. Original title.
2. Journal headline.
3. Authors' names.
4. Subject headings.

When the **Journal** article contains discussion, the names of the discussers are also listed.

The 1956 INDEX covers all material published in the **Journal** during 1956, based on the following:

1. Papers presented at national Meetings.
2. Papers presented at Section Meetings, received at SAE Headquarters.
3. Round table and production panel reports received at SAE Headquarters.

About SAE


Chesebrough


Oehler


Pickard


DeCapua


Schleicher


Olson


Braun


Jenkins

HARRY E. CHESEBROUGH, with Chrysler Corp. for 25 years in capacities ranging from student to executive engineer, has been named director of Product Planning for the Corporation.

In his new position Chesebrough will be one of the top executives of the corporation reporting directly to **E. C. ROW,** administrative vice-president.

He will co-ordinate and integrate plans of the Operating Division groups and central staffs for future automobiles and trucks. Chesebrough joined Chrysler Corp. in 1932 upon graduation as a mechanical engineer from the University of Michigan. After receiving his Masters Degree in automotive engineering at the Chrysler Institute of Engineering his first assignment was as a project engineer in the mechanical laboratory of the Engineering Division.

In 1937 he was named supervisor of the Transmission Laboratory and a year later became supervisor of all road tests for the Engineering Division.

In 1942 he became assistant chief engineer for the DeSoto Division and a project engineer for DeSoto Aircraft Production during World War II. He was appointed chief engineer for DeSoto in 1945 and four years later went to the Dodge Division in the same capacity.

Chesebrough returned to the Engineering Division in 1950 as assistant chief body engineer and a year later was appointed chief body engineer responsible for development of bodies for all Chrysler Corp. cars and trucks.

In 1955 he was named executive engineer responsible for coordinating product and programming in the Engineering Division.

As an active member of SAE, Chesebrough served as Detroit Section chairman in 1954–1955 and is also a past-chairman of SAE Meetings Committee.

ELGIN OEHLER has been named assistant manager, central staff, Federal-Mogul Service Division, Federal-Mogul-Bower Bearings, Inc. He had been manager of the company's Pittsburgh district since 1949. Oehler joined Federal-Mogul Service in 1946 as a salesman in Dallas, Tex.

EDWIN C. PICKARD, chief trim engineer for Ford Motor Co., is transferring to the Ford International Division, Ford Motor Co., on a temporary assignment as consultant engineer in the company's European operations. He will be stationed at Cologne, Germany. Pickard has accepted this assignment in lieu of his planned retirement. Pickard started in the trim field in 1909 with the Pontiac Buggy Co. and later joined the Oakland Motor Car Co.

He has been trim engineer for the Hupp Motor Co., Murray Corp., Budd Mfg. Co., Packard Motor Car Co., Chevrolet Light Car Division, and for the past nine years has served as chief trim engineer at Ford. In addition to having served as chairman of the SAE Seating Committee, Pickard has written several papers on seat design for the Society.

WILLIAM T. DeCAPUA has joined Henney Motor Co., Inc., Canastota, N. Y. as works manager. Prior to this appointment, he was vice-president and director of engineering at Wayne Works, Inc., Richmond, Ind.

DeCapua is a veteran of over 20 years in the automotive industry. He began his automotive career with Twin Coach Co. as chief engineer, transit buses. Later he was made chief engineer, Transit Bus Division, Marmon-Herrington Co., Inc.

HOWE H. HOPKINS has joined Air-cooled Motors, Inc., Syracuse, N. Y., as chief engineer. He was formerly staff enginer with Continental Aviation and Engineering Corp., Detroit.

ERNEST A. CHARLEBOIS, formerly an owner-partner in the San Diego Auto Auction, Federal Motor Sales, and Miracle Corner, has become sole owner of San Diego Auto Auction, located at 4744 Federal Boulevard, and Federal Motor Sales, located at 4706 Federal Boulevard, San Diego. He is no longer associated with Miracle Corner.

ALARIC C. SCHLIEWEN has been appointed assistant works manager of the White Motor Co. He joined the company in March, 1956, as special executive assistant to the vice-president in charge of manufacturing.

Prior to joining White, Schliewen was vice-president in charge of manufacturing of the Pierce Governor Co. from 1953 to 1956.

From 1933 to 1953, he was associated with the Mack Motor Truck Corp. He held various positions at that company including the position of plant manager of their engine transmission plant and also plant manager of their truck assembly plant.

ROY HUMMEL has been made factory manager for Champion Spark Plug Co. Previously, he was assistant factory manager for the company. Prior to joining Champion in 1947, Hummel was plant manager of the Ceramic Division of the B. G. Corp., New York City.

ROBERT W. SCHLEICHER has been named field engineer in the Indianapolis area for the General Plate Division of Metals & Controls Corp., Attleboro, Mass. Prior to joining Metals & Controls he was associated with the Nelson

Members

Hopkins

Charlebois

Schliewen

Hummel

McKinley

Podesta

Caserio

Holaday

Muffler Corp. as a sales engineer.

He also has several years of engineering experience with the Buick Motor Division and the Fisher Body Division of General Motors.

ELMER OLSON has been named to the newly created position of director of engineering and sales at the Rochester Products Division of General Motors Corp. He has served as chief engineer at Rochester Products since 1945. Prior to joining Rochester Products, Olson was employed by the Holley Carburetor Co. from 1935 to 1945 where he was in charge of automotive carburetor development and chief engineer in the automotive department.

He began his career with the Stromberg Carburetor Corp. in 1925 and served in various capacities in design, sales engineering, laboratory research, carburetor development and customer contact departments.

ADOLPH F. BRAUN succeeds Olson as chief engineer at Rochester Products. Previously, he was staff engineer of experimental engineering for the Buick Motor Division of General Motors.

Braun started at Buick in 1928 as a student engineer in the carburetor engineering section. In 1954 he was appointed staff engineer of experimental engineering for Buick in charge of all engineering test work at the GM proving grounds, dynamometer and technical data departments.

GEORGE N. JENKINS has been named assistant manager of Esso Standard Oil Co.'s Sales Engineering Division. Since 1955 he has been head of the sales engineering section that is responsible for work on automotive and aviation product quality for Esso.

Jenkins joined the Esso Research and Engineering Co. in 1943. He moved to Esso's Sales Engineering Division in 1951. Later, he served as the Detroit engineering representative of his company, working with the automobile manufacturers on product application and new-product development and testing.

DAVID K. McKINLEY is now a design engineer in the study and applied research department, Liquid Engine Division of Aerojet-General Corp. in Azusa, Calif. He was formerly a project design engineer with Wetmore Hodges and Associates, Inc., Redwood City, Calif.

McKinley has been a member of SAE Northern California Section Governing Board for the past three years as Student vice-chairman. In 1953 he was awarded the Mac Short Memorial Award of the Southern California Section.

JOHN W. PODESTA, JR., who was supervisor of employment, education, and training at General Motors Proving Ground, General Motors Corp., is now with the personnel department, engineering staff, at General Motors.

Podesta joined GM in 1951 at the Proving Ground, served with the U. S. Army for two years, and in 1954 was assigned as a junior engineer in experimental engineering. A few months later he was made a project engineer.

In 1955 he transferred to personnel at the Proving Ground to take over the supervision of their education and training program.

MARTIN J. CASERIO, chief engineer of automotive products and research for AC Spark Plug Division of General Motors since 1953, has been promoted to a new position as director of engineering and equipment sales at AC Spark Plug.

Caserio joined the company in 1937 as an engineer in metal research. Since that time he has held the positions of superintendent, chief metallurgist, supervisor of process and development engineering, military products engineer, and resident assistant chief engineer.

WILLIAM M. HOLADAY, formerly head of the research and development activities of Socony Mobil Oil Co., has resigned from the company to become deputy assistant secretary of defense—research and development.

Holaday has been on leave of absence from the company since Feb. 1, 1956, serving, in this capacity, with headquarters in Washington.

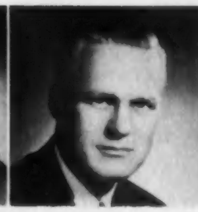
FOSTER N. PERRY has been elected chairman of the board of directors of the Robert Bosch Corp., the American subsidiary of Robert Bosch GmbH, Stuttgart, Germany. Perry, who continues at the same time as special representative of the parent company, had previously been associated with the American Bosch Corp., Springfield, Mass., for 32 years, the last five as executive vice-president.

A. KENNETH HANNUM has been appointed chief engineer of the Replacement Division of Thompson Products, Inc. He was a project engineer in the company's central staff automotive development group.

Hannum joined Thompson as an engineering trainee in 1948, and later moved to research assignments.

W. D. NELSON has joined the Walker Forge Co., Racine, Wis., as a sales engineer. Previously, he was a sales engineer with Modine Mfg. Co. in Racine.


Loofburrow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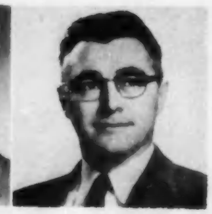
Anderson


Gillick


Cipolla


Forester


Ottmar


Steckling

Three engineers have been given new executive assignments in Chrysler Corp.'s Engineering Division.

ALAN G. LOOFBURROW, executive engineer—car chassis, electrical and truck engineering since 1955, was named executive engineer—product development and planning.

H. R. STEDING, executive engineer—management planning since 1955, was named executive engineer-product programming.

ROBERT ANDERSON, chief engineer at Plymouth Division since 1953, was named to succeed Loofburrow as executive engineer—car chassis, electrical and truck engineering.

All three will report to **PAUL C. ACKERMAN**, Chrysler Corp. vice-president and director of engineering.

THOMAS J. GILLICK, JR. has been appointed manager of the Engineering and Research Division of American Felt Co. He was director of engineering activities for the company.

From 1949, when Gillick joined American Felt, to 1954, he was chief chemist and director of quality control at the company's Glenville, Conn., plant. He was appointed director of engineering in 1954.

Prior to joining American Felt, he had been a research chemist and colorist with the Hat Corp. of America and a dyer with George A. McLachlan & Sons, hat manufacturers.

JOSEPH A. CIPOLLA has joined McCulloch Motors Corp., Los Angeles, as director of the experimental test department. Prior to this appointment, he had been staff engineer, research and engineering, Ethyl Corp.

Cipolla had been with Ethyl Corp. for 16 years, having served in the capacities of research engineer, research supervisor, and most recently as staff engineer on the technical staff of the vice-president.

In his new post, he will be responsible for the development and evaluation of all McCulloch products, as well as the fabrication of experimental components for those products.

M. A. FORESTER is now manager, development engineering services, Utica-Bend Corp. Previously, he was manager, administrative engineering, Studebaker-Packard Corp.

Forester had been with Packard for 29 years, having served 13 years at the Company's proving grounds in Utica, Mich., and 16 years in the Engineering Division of Packard.

Forester has served as SAE Detroit Section Meetings chairman and currently is a member of the Pasenger Car Activity Committee.

JEROME OTTMAR, vice-president of Metals & Controls Corp., has been named general manager of the newly organized Nuclear Products Division.

Ottmar has played a leading role in the company's nuclear work since 1952 when the Atomic Energy Commission gave the company its first experimental order.

Ottmar has been with the company since 1938. He was made a vice-president in 1953 and manager of the Spencer Thermostat Division in 1954.

ARNOLD W. STECKLING has been named chief engineer of the Plymouth Division, Chrysler Corp. He came to Plymouth from Chrysler's engineering proving grounds, where he was assistant chief engineer in charge of vehicle testing.

Steckling joined the Chrysler Dynamometer Laboratory at central engineering in 1938. At the outbreak of World War II he was made a project engineer. After the war, he was assistant supervisor, then supervisor of the road test garage in Highland Park, Mich. It was from this position that he was transferred to the Chrysler proving grounds in 1953 as assistant chief engineer.

LOUIS POLK, chairman of the board and president of the Sheffield Corp., has been elected vice-president, director, group executive, and member of the administration committee of Bendix Aviation Corp.

Polk's election follows the recent acquisition by Bendix of the business and assets of Sheffield.

He has served since 1941 as president and since 1947 as chairman of Sheffield.

Polk began in industry in 1926 at City Machine & Tool Works. In 1934 he became vice-president and general manager of the company when it was enlarged as the Cimatool Co. and in the same year became vice-president and general manager of the Sheffield Gage Corp. The two companies were combined in 1941 as the Sheffield Corp. with Polk as president.

DR. ROSS A. McFARLAND, associate professor of industrial hygiene at the Harvard School of Public Health has been presented the 1956 John Jeffries Award of the Institute of the Aeronautical Sciences. He was honored "for outstanding contributions to the advancement of aeronautics through medical research."

LEON CLAYTON HUMMEL has joined Temco Aircraft Corp. as a hydraulics engineer. Prior to appointment he was a junior engineer, Buda Division, Allis-Chalmers Mfg. Co.

While at Allis-Chalmers, Hummel served as an plant representative for the SAE Chicago Section Membership Committee.

CLAUD A. FENN, Clark Equipment Co. vice-president, has been appointed to a newly-created position on the president's staff to coordinate manufacturing operations in all Clark plants.

In his new capacity, Fenn will be accountable for all Clark property, buildings, equipment, and manufacturing policies and procedures.

Starting with Clark in 1934, Fenn has held positions as supervisor of the Housing Division, Buchanan plant manager, and manager of all Buchanan Division sales, engineering, and manufacturing operations before being made a vice-president covering these functions.

ROBERT STEVENSON, formerly director of the engine and electrical engineering office, engineering staff, Ford Motor Co., has been appointed chief engineer, product engineering office, at Ford, reporting to the group executive—engine and foundry.

L. L. BELTZ is now chief engineer, reporting to the group executive—parts and equipment, at Ford. Formerly, he was executive engineer—electrical engineering for the company.

H. C. GREBE, previously director of the body engineering office, has been appointed chief engineer, product engineering office, reporting to group executive—metal stamping.

H. G. ENGLISH has been made chief engineer, product engineering office, reporting to group executive—transmission and axle. Prior to this appointment, he was executive engineer, transmission and axle for the company.

LLOYD F. CURBY is now a technical engineer—engine analysis section, Small Aircraft Engine Division, General Electric Co. Formerly, he was an analytical engineer for Detroit Diesel Engine Division, General Motors Corp.

C. E. ZWAHL, chief chemist for the engineering department of Chevrolet Motor Division, General Motors Corp., has retired after 30 years with Chevrolet and 38 years with General Motors.

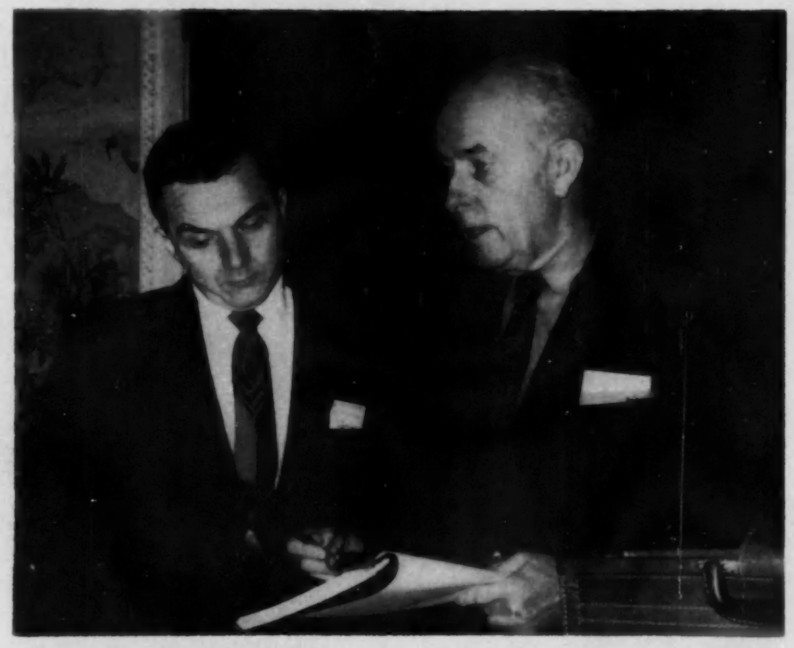
Zwahl recently was presented with a special award from Army Ordnance for nearly 12 years of advisory service on projects dealing with gear lubricants.

JOSEPH MURPHY, engineering editor, American Aviation Publications, Washington, D. C., received an award for the best operations and engineering reporting in the technical class of the 19th Annual TWA Aviation Writing and Picture Competition.

REBER C. STUPP, chief production engineer of Detroit Harvester, has been made vice-president and general manager of its subsidiary, Peters-Dalton, Inc., Detroit.

Stupp began in industry as a student engineer with the Delco Products Division plant of General Motors Corp. He started his full time career in 1922, continuing with Delco until 1947. During that time he served two years in design drafting, worked as a machine operator, a job setter, and a foreman, and in 1936 he was made a superintendent. He was made factory manager in 1940 and in 1942 he became plants manager of three plants in Dayton and two in Cincinnati, continuing in this position until 1947.

In 1947 he became vice-president in charge of manufacturing of Jack & Heintz Precision Industries and in 1948 he was made manager of the Cleveland plant of the Oliver Corp. He resigned this position in 1955 to join Detroit Harvester as chief production engineer.



GEORGE J. GUADAEN (shown above, at left) ~~takes over~~ the reins as manager of the SAE Technical Committee Division office in Detroit from **Ray C. Sackett** (above, at right).

Gaudaen, who joined the SAE staff at the beginning of the year, was the assistant to the manager of the engineering and technical department of the Automobile Manufacturers Association. Sackett will continue in the SAE Detroit office on a part-time arrangement.

As Manager of the Detroit office, Gaudaen will serve as staff secretary of SAE technical committees in the ground vehicle area—such as the Construction and Industrial Technical Committee, the Brake Committee, the Body Engineering Committee, the Tractor Technical Committee, and the Riding Comfort Research Committee.

Sackett will continue as staff secretary of the SAE Iron & Steel Technical Committee and the Non-Ferrous Metals Committee.

In his AMA responsibilities, Gaudaen worked directly on the automobile industry's technical programs on automotive headlighting and air pollution. He was secretary of the AMA Vehicle Combustion Product Subcommittee, a group that's directing an extensive industry program to find ways of controlling motor vehicle exhaust emissions.

Gaudaen also worked with an AMA committee active in developing international automotive technical standards.

Before joining AMA, Gaudaen worked for the Lincoln-Mercury Division of Ford Motor Co. as a technical writer and with the Detroit Metropolitan Aviation Authority as an airport planner. He is an active SAE member, having served as Field Editor of the Detroit Section Supercharger. Gaudaen is a graduate of Wayne University.

Sackett has been with the SAE Staff in the technical committee area since 1942. He has been, and will continue to be, a key liaison in gaining recognition for the work of SAE technical committees and extending the values of these activities to other phases of the Society's technical information services.

Sackett's new part-time arrangement at SAE will give him and Mrs. Sackett more time to travel, a past-time they enjoy so much.

JAMES CRAWFORD, retired vice-president in charge of engineering at General Motors Corp., and SAE president in 1945, has been elected president of the La Jolla Art Center, La Jolla, Calif. He has been a member of the board of directors for the Center and has served as its secretary.

PERRY W. PRATT, chief engineer of Pratt & Whitney Aircraft Division of United Aircraft Corp., has been awarded the George Westinghouse Gold Medal by the American Society of Mechanical Engineers. The medal was presented for eminent achievements in the field of aircraft propulsion.

SAE Father and Son

ROBERT SPRATT PLEXICO (left), assistant chief engineer in charge of the Truck Chassis Division, Chevrolet Motor Division, General Motors Corp., proudly displays a certificate of appreciation which he received recently from SAE recognizing his more than 35 years of active membership in the Society, to his son **Jon Lindsey Plexico** (right).

Jon, an engineering Sophomore at Princeton University, became an enrolled Student Member of SAE last year and spent the past summer in Chevrolet's new Experimental Laboratory.

AXEL W. KOGSTROM, JR. is now a planning engineer with Utica-Bend Corp., Utica, Mich. He had been liaison engineer with Studebaker-Packard Corp., Detroit.

In his new position he will head the planning group for estimating, scheduling, and expediting engineering development programs in the Utica-Bend development engineering services.

LAWRENCE P. MAMOS has joined Ford Motor Co. of Canada Ltd. as a chassis design engineer. Previously, he was a senior designer at Massey-Harris-Ferguson, Ltd.

RICHARD R. GOODWIN, previously a project design engineer, Chevrolet Motor Division, General Motors Corp., is now a field engineer, Automotive Division, Kaydon Engineering Corp., Muskegon, Mich.

Before joining the Chevrolet Motor Division, Goodwin was a project engineer, automotive air conditioning, Chevrolet Engineering Center. He also worked for the Holley Carburetor Co. as a staff engineer and for the Chrysler Corp. as a junior engineer in heating and air conditioning.

JOHN L. FINKELMANN is now in charge of the lubricants department, Cycleweld Division, Chrysler Corp. Formerly, he was vice-president of the Warren Refining and Chemical Co., Cleveland.

He will be responsible for organizing the lubricant manufacturing program including direction of sales, development, and manufacturing.

IVAN N. SCHATZKA is now a project engineer, chassis, Willys Motors, Inc. Formerly, he was a project engineer at Studebaker-Packard Corp.

THEODORE J. ZELLER, vice-president and chief engineer, Mack Trucks, Inc., will head a new forward planning department for the company.

WALTER M. MAY has been elected a vice-president and named director of engineering for Mack Trucks. Previously, he was chief engineer for the company.

WILLIAM E. BLISS, formerly a project engineer at International Harvester Co. in Emeryville, Calif., has been transferred to International Harvester's Fort Wayne, Ind., plant.

JOHN T. McCOY, manufacturing department coordinator, Tidewater Oil Co., has been named chairman of the newly organized supply and distribution committee at Tidewater's Eastern Division. The committee will coordinate crude oil supply, refinery production, product distribution inventories, and will also make recommendations to the divisional operating committee.

HARRISON W. HOLZAPFEL, formerly on the engineering staff of the Garrett Corp's AiResearch Manufacturing Division, Los Angeles, has been named assistant manager of Garrett's AiResearch Aviation Service Division.

Before joining the Garrett organization in the early part of 1956, Holzapfel had been engineering manager at Western Airlines.

HERBERT M. BRADBURY has been named director of engineering for Skymotive, Inc., Park Ridge, Ill. Prior to joining Skymotive, he was director of engineering at Aerodex, Inc.

WILLIAM R. WEST has joined the Bettis plant, atomic power research laboratory which Westinghouse Electric Corp. operates for the Atomic Energy Commission. He had been serving as lieutenant, junior grade, with the U. S. Navy.

FLOYD F. RECHLIN has joined Solar Aircraft Co. as project engineer for Solite. He had been with the Alloy Engineering and Casting Co. of Champaign, Ill. as field project engineer.

Rechlin had previously worked as a senior design engineer for powerplant installation at Rohr Aircraft, San Diego, and as a design engineer for the Terrier missile project at Convair, San Diego.

WILLIAM T. COLLINS, JR. has joined the Research and Product Development Division, Yale & Towne Mfg. Co. as a test engineer. Previously, he was a second lieutenant, Department of the Army, Ordnance Corps, Aberdeen Proving Ground.

STANLEY H. PROFFITT is now a project engineer, controls, aircraft nuclear propulsion department, General Electric Co. Formerly, he was a subsection manager, controls, aircraft accessory turbine department, at General Electric.

RICHARD C. ANSTINE has joined Knaus Truck Lines of Kansas City, Mo. Anstine recently was graduated from Tri-State College.

PETER M. SARLES has been appointed staff assistant to the works manager, Aviation Gas Turbine Division, Westinghouse Electric Corp. He was midwest area sales representative for Westinghouse Jet Division.

ROLAND C. BERGH, formerly chief, staff training, Republic Aviation Corp., has been made staff engineer, special assignments, for Republic.

In his new position Bergh will be in charge of the noise abatement program reporting directly to the president of the company.

Bergh is an active SAE member, having served as vice-chairman for aeronautics in the Metropolitan Section in 1955–1956, as a member of the executive committee, National Aeronautic Spring Meeting in 1955–1956 and 1956–1957, and as a member of Aircraft Activity Committee in 1955–1956 and 1956–1957.

RALPH E. TUTTLE is now an engineer with General Electric Co., in San Jose, Calif. Previously, he was an engineer with North American Aviation, Inc.

ELEANOR ALLEN is now managing editor of SAE Journal, and will continue as editor of SAE Transactions. Miss Allen has been a technical editor of SAE Journal and had supervision of SAE Transactions since she joined the SAE Publication Division 14 years ago.

ROBERT F. SUTTON, JR. has joined the Glenn L. Martin Co., Baltimore, as senior engineer. Previously, he was research engineer for Ford Motor Co.

CHARLES L. CUTTER has joined the Torrington Co., South Bend, Ind. Formerly, he was with Reeves Pulley Co. as a design engineer.

HOWARD L. ROAT has been named manufacturing manager for AC Spark Plug Division of General Motors Corp. Previously he was director of production engineering for the division.

DONALD M. HORNING is now an engineering designer with P. R. Mallory Co., Indianapolis. Formerly, he was an engineering designer, LeTourneau-Westinghouse, Inc.

JOHN A. SZABO is now a systems engineer with Stromberg-Carlson Co. Prior to joining Stromberg-Carlson, he was an electronics engineer with McDonnell Aircraft Corp.

DONALD H. NELSON has been made general master mechanic of the Highland Park plant, Chrysler Corp. He had been chief tool designer in the master mechanic's department of the plant.

Nelson became associated with the Chrysler Corp. at the Highland Park plant as a tool engineer in 1944.

J. EDWARD C. ANDERSON is now a research engineer with the Gabriel Co. of Cleveland. Previously, he was a project engineer with Pesco Products Division of Borg-Warner Corp.

Father and Son Make Canadian Section History

For the first time in its 28 years of existence, "like father, like son" occurs in 1956–1957 in the chairmanship of the Canadian Section.

ALEX L. GRAY (right), vice-president and general manager of Gray Forgings & Stampings, Toronto, is congratulated by his father, **ALEXANDER GRAY**, president and treasurer of the same company, on his ascendency to the chairmanship of the Canadian Section.

The elder Gray was chairman of the Canadian Section in 1943–1944.

FRANCES L. WEEDEN has been made SAE Headquarters staff representative for the Society's three aeronautic Activities and become an associate editor of SAE Journal. Miss Weeden joined the SAE Journal staff 10 years ago as a technical editor and has been managing editor since 1955.

MAX D. MURRAY is now an operations engineer, west coast, Wright Aeronautical Division, Curtiss-Wright Corp. Previously, he was a project engineer, sales, for the division.

EDWARD A. JAMISON, national supervisor LP-gas sales, Gulf Oil Corp., is on loan to British American Oil Co., Ltd. He will supervise sales of LP-gas and the training of personnel at British American Oil Co.

ROBERT E. LOREN is now technical publication engineer, small aircraft engine department, General Electric Co. Formerly, he was a field engineer, Wright Aeronautical Division, Curtiss-Wright Corp.

JACK W. FRENCH has been appointed executive engineer–advanced engineering, Edsel Division, Ford Motor Co. He had been chief engineer, staff advanced vehicles department, at Ford. Before joining Ford in 1954 as section supervisor, advance car package section of the staff advanced vehicles department, he worked on guided missiles and rocket engine development at North American Aviation.

FRANK S. TRECO, JR. has been appointed to the new post of sales manager of Clevite Harris Products, Inc. Formerly a Clevite Harris sales engineer in Detroit, Treco now will direct all sales activities except for the company's Special Products Division.

R. L. MORRISON has resigned as executive vice-president and a director of the De Vilbiss Co., Toledo, Ohio. He will continue his affiliation with the company as general consultant and will be associated with the Somerset Auto Parts Inc., Somerset, Pa.

Perfect Circle Changes

Thomas

Austin

Shelly

Reed

Johnson

ROBERT M. THOMAS has been appointed to the newly created post of staff sales consultant for Perfect Circle Corp. Prior to this appointment, he was sales manager for the corporation's Manufacturers' Division.

In this new position, Thomas will investigate sales potentials and plan sales programs for new products under study by Perfect Circle.

He joined Perfect Circle in 1932 when he became the first vice-president and general manager of Perfect Circle Co., Ltd., Canadian subsidiary of Perfect Circle. He remained at that post for 11 years and then transferred to the parent company as sales manager of the Manufacturers' Division. He has served in that capacity for 13 years.

RUFUS P. AUSTIN, now assistant sales manager of the Manufacturers' Division, will succeed Thomas as sales manager of the division.

He joined Perfect Circle in 1926 as a clerk in the production office. In a series of promotions, Austin became assistant manager of the Hagerstown plant and later production control manager for the corporation. He has served 12 years in his most recent position of assistant sales manager and for the past eight years has been in charge of the firm's Detroit and Chicago offices.

RALPH A. SHELLY, manager of manufacturers' service sales for Perfect Circle, has been appointed to the sales committee of the corporation.

In addition to his present duties, Shelly will be responsible for coordinating all piston ring prices for manufacturers' service, export, and domestic jobber markets.

Shelly has been connected with the merchandising, sales, and service of automobiles and trucks for the past 40 years. He has been with Perfect Circle since 1944.

JOSEPH H. REED has been named assistant sales manager of the Manufacturers' Sales Division in charge of the staff at the Chicago office. For the past 12 years, Reed has been a sales engineer in the company's Chicago office.

Reed joined the Perfect Circle's Replacement Division in 1937 as a field representative and later became district manager. He transferred to the Manufacturers' Sale Division in 1942 and for two years was attached to the main office staff.

WALTER E. JOHNSON has been named to head the Detroit office of the company's Manufacturers' Sales Division. He had been a sales engineer in the division's Detroit office since 1953.

Johnson joined Perfect Circle in 1944 as an engineer in the service department. He moved to the Manufacturers' Sales Division in 1946.

RALPH J. ESCHBORN has been elected vice-president of Jack & Heintz, Inc. He formerly was chief engineer for the firm, and now will be responsible for all engineering activities of the firm.

Joining Jack & Heintz in 1951 as a staff engineer, Eschborn was named engineering executive manager a year later. He became assistant chief engineer in 1953 and chief engineer in 1955.

Before joining J & H, Eschborn was an aeronautical research scientist with the Lewis Flight Propulsion Laboratory, N.A.C.A., and previously was assistant director of the University of Kentucky's aeronautical research laboratory.

THEODORE L. PREBLE has been named supervisor of trucking for Tidewater Oil Co. He had been Eastern Division automotive supervisor for the company.

Preble joined Tidewater in 1934 as supervisor of automotive equipment.

A. D. UPDYKE has been made senior project engineer at Sperry Utah Engineering Laboratory, Salt Lake City, Utah. He was a product engineer with Sperry Farragut Co. in Bristol, Tenn.

PETER C. HORNER is now a product development engineer, Thunderbird development group, Ford Motor Co. Formerly, he was a product development engineer at Ford's Dearborn test area.

EDMUND O. SCHROEDER has been named vice-president of maintenance for Seaboard & Western Airlines, Inc. Prior to this appointment, he was assistant vice-president at American Airlines, Inc.

HENRY A. WEBER has joined Solar Aircraft Co. as a project engineer on gas turbine engine development. He formerly was associated with the Wright Aeronautical Division of Curtiss-Wright Corp. During his eight years there, he was concerned with reciprocating and turbojet engines, experimental engineering, performance analysis, project engineering, and most recently, engine development work.

J. W. MAXEY has been appointed superintendent of the powerplant and building service, piping and plumbing, building and facilities department, Ford Motor Co. He had been assistant supervisor, plant engineering section at Ford.

E. R. DONNER is now a sales engineer with Standard Oil Co. of Calif. Formerly, he was a fuels and lubricants engineer with the company.

Donner, has served as secretary of SAE Spokane-Intermountain Section, and is also a past-chairman of the Salt Lake Group.

CASIMIR S. REJENT JR. is now a product engineer with Thompson Products, Inc. Formerly, he was a development engineer with the company.

WILSON P. GREEN has been named to the newly created post of technical director of the Parker Pen Co.'s Planning Division. He joined Parker last summer as director of product development.

Green had formerly served as manager of a research department for the Armour Research Foundation in Chicago.

DONALD H. SPICER, has resigned as vice-president in charge of sales at Morse Chain Co. He now is self-employed as a manufacturer's agent, selling to automotive manufacturers, distributors, and dealers.

WILLIAM A. CODA is now an automotive sales engineer, Georgia Webbing & Tape Co. Prior to this appointment, he was a sales engineer with Craicomb Sales & Mfg. Co.

CARL D. TAULBEE is now a nuclear engineer with Bendix Aviation Corp. He had been a project engineer with Studebaker-Packard Corp.

CARL J. MILLER is now a senior design engineer, Pontiac Division, General Motors Corp. Prior to joining Pontiac, he was a senior designer with the Studebaker-Packard Corp.

R. J. Di CICCO has been appointed chief mechanical engineer for all four mines and mills of Asbestos Corp. Ltd., Thetford Mines, Quebec. For the past year Di Cicco has been maintenance superintendent of Asbestos Corp.'s King Mine.

Before joining Asbestos, he was woodland mechanical engineer for the Consolidated Paper Corp., Ltd.

ROY WELLINGTON is now a junior designer with Pratt and Whitney Aircraft Division of United Aircraft Corp. Formerly, he was a draftsman for Continental Motors Corp.

Wellington's SAE activities include serving as Western Michigan Section Reception Committee chairman in 1954–1955.

BARRETT B. RUSSELL has been made assistant regional manager, gulf coast region, E. I. DuPont de Nemours and Co., Inc. Prior to this appointment, he was assistant regional manager, mid continent region for DuPont.

JAMES C. BURKE has joined Arthur D. Little, Inc., Cambridge, as a mechanical engineer. Previously, he was associate research engineer "A" at Boeing Airplane Co., Seattle.

JOHN T. REDMON has been elected president of the Detroit No. 1 Kiwanis Club. He is Detroit district manager of Globe-Union Inc.

DR. ROBERT E. WILSON, chairman of the board, Standard Oil Co. of Indiana, was presented a certificate of appreciation by the American Petroleum Institute for fundamental research.

JOSEPH M. BROWN is now president and chairman of the board of Structure Specialties, Inc., Santa Monica, Calif. Formerly, he had been strength engineer at Douglas Aircraft Co. in Santa Monica.

L. C. DANIELS, has been named general manager, Buda Division, Allis-Chalmers Mfg. Co., tractor group. Prior to this new appointment, he was vice-president, material handling department, Buda Division.

ELBERT C. SMITH has been named assistant to the associate director, Brookhaven National Laboratory. Prior to this appointment, he was administrative engineer, Rocketdyne Division, North American Aviation, Inc.

L. L. COLBERT, president of Chrysler Corp., was honored at a dinner sponsored by the National Conference of Christians and Jews, in recognition of his work as 1955–1956 chairman of the Special Gifts Committee of the Conference.

M. A. McPHAIL has been made shop foreman at Trapp Motors Ltd., New Westminister, British Columbia. He was service manager at Trapp.

ARTHUR E. SMITH, JR. is now president of New Brunswick Motors, Inc., a Lincoln-Mercury automotive sales and service dealership. Formerly, he was general manager of Smith and Gregory of New York, Inc.

SANVUS YUEN is now a private with the U. S. Army. Previously, he had been a project engineer trainee in the advance truck department at Ford Motor Co.

H. WILLIAM GILBERT is now senior engineer—body engineering, Engineering Division, Chrysler Corp. Previously, he was specialist third class, Department of the Army, Dugway Proving Ground, Dugway, Utah.

JOSEPH P. SEAMONS, project engineer, Lockheed Aircraft Corp., has been named to head the newly organized consolidation of all super constellation design engineering for Lockheed.

Seamons has been with Lockheed for the past 16 years, and has been associated with the aircraft industry for more than 30 years.

A. L. Boegehold Predicts . . .

1. Engine weights and car weights will go down.

2. Engine efficiency will increase.

3. We will use light alloys generously to supplement increased efficiency as a means of conserving fuel.

4. Otherwise, materials will be much the same as those now used but with less nickel and with more pearlitic malleable iron.

5. The powerplant of the future will have low weight per horsepower, low volume per horsepower, and good fuel economy.

The race between the present type engine, the gas turbine, and the free piston engine will be interesting and exciting. Size, weight, and performance of the gasoline piston engine, which must be exceeded by the gas turbine or the free piston engine, are targets that will not stand still. Improvements we can see on the way, make it appear that piston engines will be our powerplants for many years to come.

(Paper "Materials in the Automobile of the Future" on which this article is based, was presented by A. L. Boegehold, manager of research staff activities, GMC.)

Communication Is Your Problem

Based on secretary's report

F. W. SWARD
Thompson Products, Inc.

GOOD communications is inseparable from good human relations and understanding. Only by knowing your audience, your medium, and your subject will you be able to put your ideas across.

Communications is not an abstract commodity. It is linked with personalities, experiences, knowledge, desires, economics, prejudices, and previous misunderstandings. For that reason, all our communications must be adjusted to the receiver if they are to be understood and effective. Keep these rules in mind:

- Know the people to whom you are communicating.
- Know what they want to hear.
- Know how they want to hear it and where.

The accuracy and timing of communications is important. Too much may

be worse than none at all, and there should be a balance between oral and written communications. If the information given in a communication is insufficient it may cost time and money.

Explaining individual responsibilities at all levels is one of the best ways to get effective communication. This requires maximum attention continuously from the president down to the most menial operator. The procedure has a chain effect and is, of course, subject to weak links—the key persons who are poor communicators. These people may prevent useful ideas from coming up where they can be heard by top management.

To overcome this weakness various techniques have been tried. Independent surveys may be used to get people to explain their problems, but these are often slow and limited in scope. They can be useful in bringing "beefs" out into the open. And if the employee writes out his grievance, the act of writing and then seeing it may be healing.

Management is to be heard, but it also must listen. A congenial attitude helps. Much listening can be done by looking. Regularly scheduled meetings with employees, if well organized, give an opportunity for management to express objectives and to get on-the-spot reports of progress.

No one is too busy to communicate. It is nice to be important, but it is even more important to be nice. Courtesy is indispensable in building better human relations. (Based on secretary's report of a panel on Communications in Plant Operation. Members of the panel were: C. W. Goldbeck, Thompson Products, Inc., panel leader; F. W. Sward, Thompson Products, Inc., panel secretary. Panel members: R. L. Howes, General Electric Co.; P. H. Neville, The Leece-Neville Co.; N. G. Shidle, SAE Journal; G. D. Wolfe, The Heil Co. This report together with 7 other panel reports are available as SP-316 from SAE Special Publications Dept., 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.)

Investment Process Makes Accurate Castings

Based on paper by

J. O. GARRETT

Gray-Syracuse, Inc.

THE investment process permits casting of intricate designs to tolerances as close as 0.005 in. per in. of length. Machining can usually be eliminated on an investment cast. This permits

the difficult-to-machine alloys to be cast with little waste. Surface finishes of 125 or better are usually obtained.

Tooling and pattern costs for the investment process are generally low and even assemblies can be cast.

The process is as follows:

1. A wax or plastic pattern is made from a mold which can be cast or machined. For wax, the mold is made from lead or aluminum. For plastics, the mold must be made from steel.
2. The patterns are arranged in clusters in a stainless flask and a slurry similar to plaster of Paris is poured over them.
3. Suitable gating is provided and the flask is placed in a furnace heated to 1800 F. This melts the wax and is known as "burn-out."
4. The castings are then poured.
5. Cooling is followed by cut-off and clean up.

The flexibility of the process can be demonstrated by an example. A manufacturer was having difficulty with a governor weight which would not stand up to a military drop test. The investment foundry supplied test bars from which new weights were machined.

These withstood the test so it was decided to go ahead with investment castings. Since early delivery was important, a pattern was made from a machined part which was copper plated to allow for shrinkage. From this a single-cavity mold was poured and prototype investment castings made.

When these proved successful, two sets of temporary 3-cavity lead molds were made and production started within three weeks with this temporary tooling.

Meanwhile, work was started on steel molds for plastic patterns. From the final molds approximately 250,000 pieces were made.

(Paper "Investment Castings" was presented before Syracuse Section of SAE.)

Integrated Controls Need More Reliability

Based on paper by

R. HADEKEL
Sperry Gyroscope Co., Ltd.

PROBLEMS associated with high-speed flight determine integrated control systems.

These systems may be relatively sim-

ple powered controls, such as an autopilot. Or they may be highly sophisticated systems . . . with all-electric signalling and, perhaps, triplicate actuators bristling with automatic safety devices. Whatever the type, reliability is likely to remain the central problem.

Automatic flight control and artificial stabilization both begin with sensing instruments to detect the aircraft's departure from the desired path and the wanted state of uniform oscillation-free motion. These instruments are the essential source of information for any automatic system and they may be of many kinds, including gyroscopes, aerodynamics sensors, and radio apparatus. The information is fed to a central control device, most aptly described as a computer, which determines the control surface movements (and possibly movements of other control organs such as engine throttles) required to damp out oscillations and to maintain the desired path. The computer sends out suitable signals to the actuators which operate the control surfaces which are moved the desired amount. And the airframe "closes the loop."

The pilot, too, must be given his say and allowed to fly the airplane when he must, or when he wishes to. So he, too, must be allowed to send signals to the actuators, in other words, the system must be capable of accepting demand signals from the pilot as well as from the instruments-computer setup. Two of the main ways of providing for this are:

1. The actuators may be arranged to accept either signals from the computer only, or signals from the pilot and computer together.

2. The computer may be arranged, when required, to accept signals from the pilot and reinterpret them before passing them on to the actuators.

At present there is no tendency to depart from the established hydraulic cylinder and valve type of actuator. In simplest form this may consist of a moving cylinder with the valve mounted on it. There is much to be said for this construction even though it requires a mechanical differential lever.

The essential difference between an ordinary powered-control actuator and an actuator for an integrated system is that the latter must be controllable by a computer and must therefore understand the computer's language, which is electrical and likely to remain so. The control valve, therefore, must respond to electrical signals, that is, it must be driven by some form of torque motor.

Furthermore, the actuator must usually report its position back to the computer, hence must be fitted with some electrical position pick-off device—potentiometer, synchro, or anything that will do the job. This is a matter of convenience and not an absolute necessity, as it is quite conceivable to have open-loop control of the actuators, for

instance, by arranging the computer to move the valve by an amount appropriate to the required rate of movement of the control surface. In practice, such a control would be rather crude, but it could be refined by using velocity feedback from the actuator, or other forms of feedback such as force or acceleration.

In these days of servomechanisms, transmission of mechanical motion by means of a long system of rods, cables, levers, torque shafts and the like, is a clumsy way of gaining a simple objective, however, the inherent reliability of such a system has been proved and cannot be ignored. If electrical position signalling is to achieve a comparable degree of reliability, then duplicate signalling at least must be provided, with automatic means for coping with failures. It is a question whether in themselves the advantages of electrical signalling would then be sufficient to justify the complications involved.

There is also the question of reliability of hydraulic components and supplies. One way to solve both these problems simultaneously is for each control surface to be driven by three actuators in parallel, each with its own hydraulic supply, electric signalling devices, wiring, and networks, and certain basic instruments, possibly rate gyros. The system would then be such that, at least in the manual control mode, any single failure would affect only one channel. Whatever the fault, the actuator in the faulty channel would be overpowered by the other two. Systems of this type could not stand two failures in general, but can be arranged to stand certain combinations of two failures. If any combination of two failures is to be tolerated, quadruplication would seem to be inevitable.

As electrical components, wiring fittings, and other items become more reliable, such extreme measures as quadruplication may become unnecessary. There are difficulties in synchronizing three actuators, not to mention four, but in some respects all-electric signalling facilitates actuator design. In the first place, a valve which needs only electrical actuation is going to be simpler than one which has to accept both electrical and mechanical inputs. Then, too, there is no need for mechanical differentials or moving cylinder arrangements, both of which are a nuisance. Finally, there is far less likelihood of instability due to structural feedbacks through the signalling system. (Based on paper "Integrated Control Systems for Aircraft." It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

New Series Parallel System Has Simplicity

Based on paper by

J. V. POTICNY

The Leece-Neville Co.

A NEW 12-24v series parallel charging and cranking circuit is now available for trucks and buses. Features of this system are:

1. A series parallel switch and a magnetic switch are combined into a single unit.

2. The single unit requires less wiring than the former double unit. This lessens the possibility of line

losses and the mixing or reversing of wires.

3. Less current is required to operate the coil of one switch than was needed for the previous two units.

4. If the magnetic switch contacts welded in the former two-switch system, a damaging short circuit occurred. This is impossible with the new single unit switch because both sets of contacts are mounted on the same plunger shaft assembly. If a short circuit occurs and one set of contacts welds shut, the other contactor will assume a position midway between its upper and lower fixed contacts when the starter button is released. This fail-safe feature eliminates the need for fuses or circuit breakers in the charging system.

The charging circuit can be traced by reference to Fig. 1. The generator output lead is connected to bottom left charging terminal marked 2, through external copper strap to negative terminal of No. 1 battery. With the positive terminal of this battery grounded, the circuit returns to the generator through ground. The No. 2 battery circuit can be traced from the same bottom left charging contact marked 2, (through main contactor) to upper left charging contact marked 2, through external copper strap to negative terminal of No. 2 battery. Ground return of this battery is through the right hand set of charging contacts marked 2.

The charging contacts can be very large to accommodate 180 amp alternators or even higher and there are no fuses or circuit breakers. Larger area contacts and absence of fuses reduces the resistance formerly imposed in the circuit of the No. 2 battery.

The cranking circuit can be followed by reference to Fig. 2. It starts with No. 1 battery. Its positive terminal is grounded and negative terminal connected to the SPS stationary series contacts marked 3, (bridged by a main contactor) to positive terminal of No. 2 battery. The negative terminal of No. 2 battery is connected to the other stationary set of cranking contacts marked 4 (bridged by a main contactor) to cranking motor, completing a 24-v circuit.

Should the main contactor weld against the stationary set of cranking contacts marked 4, due to a short in the system, then the other main contactor will assume a position midway between the upper (cranking) and lower (charging) fixed contacts. Since it cannot drop back to the charging contacts, there is no need for protective fuses or circuit breakers.

The one unit switch takes low current draw (less than 7 amp) for the energizing coil. The switch will close at less than 7 v and "hold in" down to 1.5 v. (Based on paper "New Look in Series Parallel Systems." It is available in full, in multilith form, from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

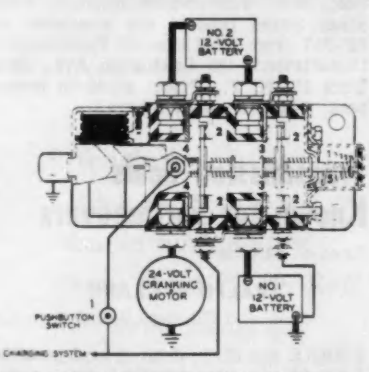


Fig. 1—Charging circuit (12v) of the new 12-24v series parallel system which combines a serial parallel switch and a magnetic switch in a single unit.

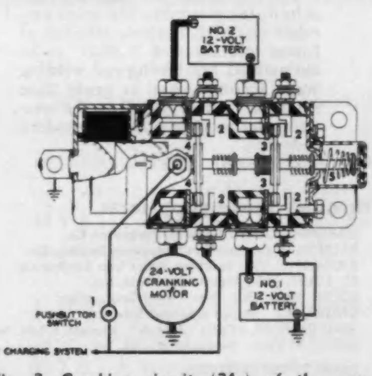


Fig. 2—Cranking circuit (24v) of the new 12-24v series parallel system now available for truck and bus installation.

Numerals denote:
1. When pushbutton switch is closed, coil is energized from No. 1 battery, actuating shaft.
2. Charging-current contacts open, disconnecting No. 2 battery from generating system.
3. Contactor connects two 12-volt batteries in series.
4. Contactor connects 24-volt cranking motor with batteries.
5. When pushbutton switch is released, spring returns contactors to original parallel charging position.

There's a Best Way To Use Quality Control

H. J. CUEVAS

Lockheed Aircraft Corp.

QUALITY control of each process in the manufacture of a part insures better quality than quality control of the final part alone. Furthermore, it saves time, money, and material.

Much quality control and inspection activity seems to take place after the fact, and to be designed more to determine if the product has been fabricated as planned rather than to insure that it will be as designed on completion. If there were violations of quality in the process, it is a little late to find it out when the part is completed, and if the violations cannot be detected in the final quality control inspection, the aim of quality is defeated.

The bonding of metals, for example, which has proved satisfactory in laboratory tests, hasn't always worked out well in production. There have been instances where there were voids and overly thick bonding films, for which the quality control people have had no immediate standards or inspection facilities, and over which they had no control during the processing.

Trouble, too, has been encountered where relatively thin skin or sheet metal is secured to much heavier structure, such as wing beam cap strips, by means of rivets or other fasteners. If the hole in the thin sheet metal is damaged, due, perhaps, to deep countersinking or poor drilling, it is customary to use the next size fastener. This removes material from the main structural member to which the skin is fastened, perhaps seriously reducing its strength, and in any event reducing the possibility of repair in that area at a later date.

Sometimes the factory workmen drive rivets into badly mutilated holes, and they may never be seen. If they are observed, reported by the workmen or caught by quality control, the inclination is still quite often to use the next size fastener.

(This article is based on the secretary's report of the panel on Quality and Process Control which was presented at the SAE National Aeronautic Production Forum. Panel leader was O. E. Erwin, Lockheed Aircraft Corp.; panel co-leader was R. H. Gilliland, Convair Division, General Dynamics Corp.; secretary, H. J. Cuevas, Lockheed Aircraft Corp. Panel members were: C. W. Andrews, Douglas Aircraft Co.; J. A. Baer, Douglas Aircraft Co.; R. L. Ellinger, Trans World Airlines, Inc.; G. Stroh, North American Aviation, Inc. This report together with other panel reports are available as SP-317 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $2.00 to members; $4.00 to nonmembers.)

Transmission Goals Known for Earthmovers

Based on paper by

RALPH B. CLARK

LeTourneau Westinghouse Co

THERE are three desired and possible conditions of operation for earthmoving equipment. These are:

- Infinite selection of speed, constant under widely varying load factor ranging from crawl to haul speeds, including the feature of optional interlocking excavating devices.
- Maximum efficiency and economy depending on load factor on engine.
- Precision operation under partial loads for finish grading.

The controls desired are four in number, as follows:

Continued on page 115

- Infinitely variable tractor speed control.
- Automatic manual interlock of blade control.
- Scraper or dozer controls.
- Maximum engine horsepower control or speed control.

There are two possible avenues of approach to attain the desired goal. These are:

- Improve torque converter design with variable torque absorption and improved speed overrun control.
- Electric drive with improved efficiency and less costly components to provide the approximately infinite torque speed relationship desired.

(Based on paper "Earthmoving Transmissions—Where Are We Going?" It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members; 60¢ to nonmembers.)

Snorkel Diesels Have Their Troubles

Based on paper by

A. H. FOX
Standard Oil Co. (Ind.)

R. A. PEJEAU
Cleveland Diesel-Engine Division, GMC

LEONARD RAYMOND
Socony Mobil Oil Co.

L. G. SCHNEIDER
N. S. Naval Engineering Experiment Station

THREE approaches are being studied to determine ways to reduce the excessive deposits, high ring and liner wear, and corrosion of chrome-plated liners being experienced on diesels operated with high sulfur fuels in submarines under snorkel conditions. These are:

1. Higher jacket temperature.
2. Lubricating oil additive level.
3. Exhaust-valve metallurgy.

In tests to date, increasing jacket water discharge temperature from 143 F to 166 F failed to improve conditions. It is felt, however, that higher temperatures might achieve an improvement.

An increase in detergent additive level of lubricant resulted in a reduction in wear, piston and combustion-chamber deposits, and liner corrosion. Unfortunately, undesirable value burning was experienced with at least one of the high additive oils used. It is possible that the increased valve seat deposits observed in this case accelerated the tendency toward valve distress.

Comparison of the valve deposit weights for all runs showed that higher additive oils contributed to heavier valve deposits. In compatibility of

specific valve materials with specific oil additives may also be a factor, although the data so far collected are too limited to shed any light on this. The large increase in exhaust temperatures during snorkel operation reduces value hot strength materially. This is believed to be a major factor in the deterioration of exhaust valves and seats.

(Based on paper "Submarines, Snorkel, and Sulfur," a progress report of the CFR-DFD Group on Deposit-Forming Characteristics of Diesel Fuels and Engines of CRC. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Overcoming the F4D's Landing Gear Failures

Based on paper by

F. W. HODGDON

Douglas Aircraft Co., Inc.

WHEN the F4D Skyray carrier-based fighter operated over a small diameter arresting cable there was no failure of the landing gear, but when larger arresting cables were introduced, service failures began immediately.

Since the shock absorbing function of the tail bumper depends upon metering oil through an orifice, experiments were tried with relief valves which would open at cable contact, thereby permitting the tail bumper to ride over the cable without a large increase in load. This attempt proved ineffective and the decision was made to redesign the tail bumper and supporting section for added strength.

Strength criteria for the redesign were derived from investigation. Loads in all sections of the tail bumper and supporting structure would be considered to be made up of two parts: one due to the basic loads by landing without contacting a cable, the other due to impact loads obtained by striking a cable. The basic landing loads would be treated according to existing criteria throughout both the gear and supporting structure. The impact portion of the load at the axle would be based on 1000 cycle response galvo results, reduced in the case of drag load by the ratio of drum test to carrier landing severity. These axle loads would then be the basis for calculating impact only loads in the gear and supporting structure. Impact loads in the various gear and supporting structure members would be further reduced by the ratio of measured to calculated loads in the particular member. This reduction accounts for the absorption of the high frequency axle load by the mass and inertia of the tail bumper.

Contact velocity and landing speed comparison drops indicated that there was no variation in the impact portion of the load due to sinking speed. However, a 15% reduction in 1000 cycle impact drag load was measured by reducing the drum speed from 95 to 75 knots.

Considerable time has been spent to set up a suitable model representing the tail bumper and supporting structure as well as some other weight items for investigation of the problem by analog computer. When a model is devised which acts in a manner similar to the actions of the test plane on the rotating drum, models of other designs will be checked.

It is possible that the "add strength" solution will not have to be used in the future. An entirely different approach may bring a final solution. It may be possible to develop a relief valve that will operate quickly enough to relieve some of the impact load. Other geometric arrangements and/or larger wheels and tires might be solutions. To date, except for cut tires, no

cable impact problems have been experienced with nose or main gears. (Based on paper "The Effect of High Frequency Impact Loads on Airplane Landing Gears." It is available in full, in multilith form, from SAE Special Publications Dept., 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Electrical Problems Hit Supersonic Flight

Based on paper by

VICTOR B. HART

Boeing Airplane Co

SUPERSONIC flight has created tremendous problems in the design of electrical equipment and components. Such items as higher voltages, corona and arc-over must be taken into consideration when designing for high performance aircraft.

The need for higher system voltage is indicated by three design factors of supersonic aircraft. These are:

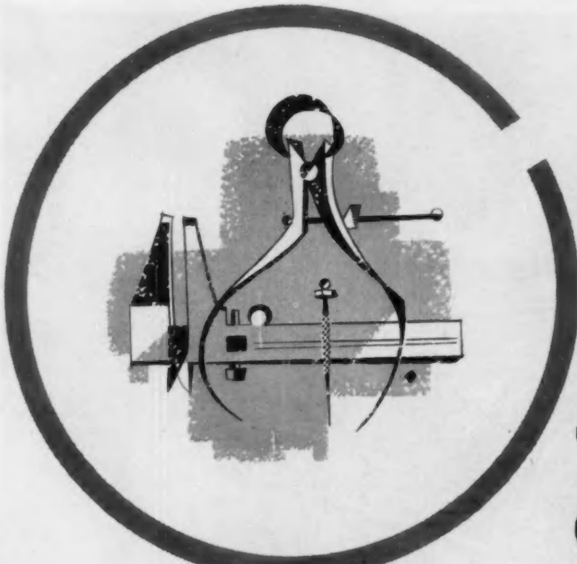
- Increased electric load demand. More automaticity, powered flight controls, new electronics, cooling requirements, and other items, all tend to raise the load demand current.

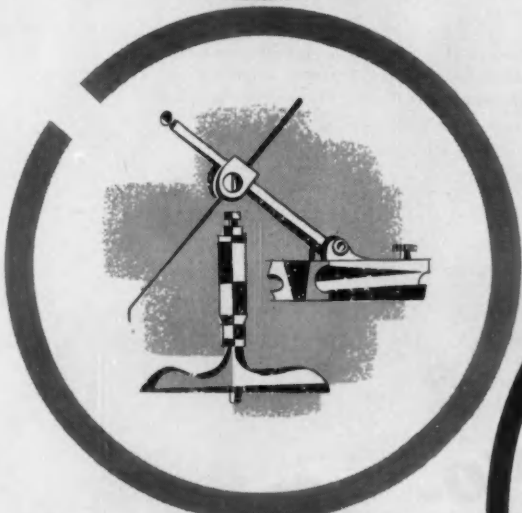
- High altitude operation. The reduced air density at high altitudes reduces the cooling ability of the wire. A typical operating altitude of 70,000 ft will cause a reduction in wire current carrying capacity of approximately 20%.

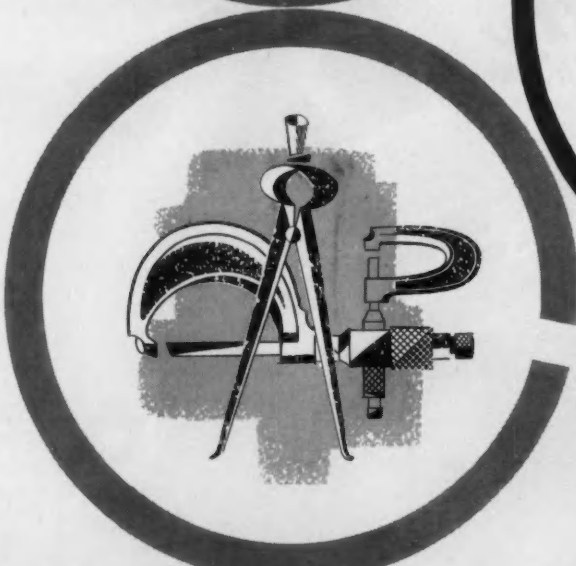
- Increased ambient temperature corresponding to higher Mach Numbers. At a conductor temperature of 750 F, conductor resistance is about 2.5 times that at room ambient temperature. Thus, it will take 2.5 times as much copper wire to conduct the same current as required at room temperature. This added wire can represent substantial weight penalties.

With an increase in operating voltage, two equipment design factors—corona and arc-over—require closer attention. Corona is an electric phenomenon which can be present in high voltage circuits. It occurs when the potential of a conductor in air exceeds the dielectric strength of the surrounding air and is due to ionization of the air. It is apparent sometimes as a purplish discharge around a conductor or between conductors, but can be detected as a radio noise much below the visual level.

Corona starting voltages vary with air density. As altitudes and temperature are increased, air density is increased. Corona starting voltage for







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Tru-Rol *precision, steel-cage, heavy-duty bearing with contoured guide lips assuring true right-line rolling, maintained roller alignment and thin oil film.*

● Rollway's *TRU-ROL* Steel-Cage Bearings afford wide latitude in balancing *dependable* performance, *long* life, and *high load* capacity against *moderate* cost. They rate high in any comparison on a cost-performance basis.

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TRU-ROL offers the extra advantage of a finish-ground "crown" radius on the roller ends. That relieves high end-stress and insures uniform load distribution over the entire length of the roller. The result: *TRU-ROL* Steel Cage Bearings carry heavier loads over longer periods without excessive end-fatigue. They are less affected by slight misalignment or shaft deflection.

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● Rollway Metric Series Steel-Cage Bearings offer the greater load capacity of solid cylindrical rollers, plus the true right-line rolling of trunnion rollers turning in a rigid steel cage. There's no roller skew, no pinch out, no cam action. Design permits maximum bearing capacity . . . within small space . . . at moderate cost.

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spacings up to .25 in. are still decreasing as the altitude and temperature environments are increased to 100,000 ft and 600 F, respectively.

Corona can be harmful to insulation as well as produce radio noise. It must be controlled in the electrical system, and it can be eliminated by proper design. Methods of control are: providing adequate spacing between conductors, eliminating sharp points and corners, eliminating air between conductors, and providing a grounded shield between conductors.

Assuming a design voltage level of 560 v for a 440-volt system, a center to center spacing of about .28 in. will eliminate corona. Different types and thicknesses of insulation will affect the distance. If a grounded shield is placed around each wire insulation, corona will be eliminated without observing the spacing requirement.

Arc-over potential between bare terminals or uninsulated wire occurs before the corona starting voltage. Assuming an arc-over design voltage of about 960 v for a 440-volt system, a spacing of .7 in. will eliminate arc-over. If insulation is inserted between terminals, spacing requirements can be ignored. (Based on paper "Electric Equipment Problems in Supersonic Vehicles." It is available in full, in multilith form, from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Tips for Reducing Truck And Bus Electrical Costs

Based on paper by

H. L. HARTZELL

General Motors Corp.

TRUCK and bus electrical equipment maintenance costs are too high. Here are some recommendations on how to reduce overall electrical equipment costs.

To The Operator:

1. Order true heavy-duty electrical units where operating requirements are severe and particularly where "downtime" is very costly.

2. When passenger-car-type equipment is ordered, insist on modifications that will extend the durability.

3. Increase your efforts toward selling the manufacturers on needed corrections, frankly telling them where slight additions to vehicle costs are justified on the basis of lowered maintenance costs.

4. Establish better communications with vehicle and electrical manufacturers in order to speed up diagnosis and correction of problems.

5. Take full advantage of the field schools that are being operated to improve mechanics' skills in maintaining and servicing electrical equipment.

To The Vehicle Manufacturer:

1. Determine the best method of carrying a storage battery and use it in a cool location accessible for servicing. Adhering to this practice will result in an important reduction in maintenance costs and "downtime."

2. Supply your sales representatives with full information on the overall cost advantages of heavy-duty units. Make sure they know the difference between heavy-duty equipment and modified passenger-car equipment. When passenger-car-type equipment is indicated, make available units with maximum modification.

3. Make fewer compromises in the selection and application of electrical components.

To The Electrical Manufacturers:

1. Keep the service and product engineers in close contact with the operators. Better understanding of operating conditions is sure to help both the designer and the builder.

2. Keep vehicle and engine manufacturers posted on results of field studies.

3. Have an active program of recommending to your customers modifications that will reduce maintenance costs.

(Paper "Electrical Equipment—Heavy Duty Progress" was presented at SAE National Transportation Meeting. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

New Members Qualified

These applicants qualified for admission to the Society between January 10, 1957 and February 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section

H. Blair Minick, Jr. (J).

Baltimore Section

Robert J. Hagen (J).

British Columbia Section

Thomas A. Ameer-Beg (M), William Wong (A).

Canadian Section

John M. Allan (M), Donald L. Burrows (J), Wallace Bruce Stewart Crowston (J), John B. Johnston (A), Mervyn Elmer Nicholls (M), Robert H. Richmond (J), Horatio W. Thompson (A).

Central Illinois Section

Roland Frederick Bill (M), William W. Breitbarth (J), Wendel Brooks Crum (J), Horace J. Swinland (M), Ralph E. Watt (J).

Chicago Section

Hugo Coello (J), Donald H. Gautsch (A), Walter Graber (M), J. D. Hall (M), Frank A. Hlavacek (A), Robert James Klein (M), Joseph M. Lyons (A), Philip G. Needham (M), William G. Sheiry, Jr. (J), William Corbin Smith (J), William W. Squier (M), Herbert N. Underwood (J), Edward C. Van Buskirk (M).

Cincinnati Section

John F. Dooley, Jr. (M), Aaron Komisar (M), Kenneth T. Wilbur (M).

Cleveland Section

Judson T. Bennett (J), Robert J. Farrell (A), Andrew G. Johnson (M), Donald Sidney Johnson (J), J. D. McMillin, Jr. (M), Arthur D. Schultz (M), David J. Stevenson (J), Foster J. Young (M).

Dayton Section

James A. Guild (M), John J. Warga (A), Charles Warren Wood (M).

Detroit Section

Donald Adams (J), James A. Barbaria (M), Theodore E. Beauregard, Jr. (J), Charles P. Bolles (J), Malcolm Brown (J), Robert Earl Brown (J), Wesley B. Carlson (J), Thomas J. Clark, Jr. (J), David L. Cohoe, Jr. (J), Gene A. Crockett (M), Frank R. Davis (M), Richard F. Deremer (J), George W. Duffield (A), Robert B. Dupree, Jr. (J), James M. Erkert (M), John A. Ferrari (J), Lawrence E. Gaydos (J), George L. Giasson (A), Ronald F. Gillham (J), Russell L. Gilpin (A), Thomas Clifford Goad (J), Kenneth L. Hasselkus (J), Clare E. Hellenberg (M), Robert C. Kemp (J), John Emmett Kenealy (A), Arvan F. Kent (M), Wibrandus J. Koppius (J), Maynard E. Lagassee (J), Francois Louis (J), William C. MacNeill (A), Jay Dean McCulley (J), Ralph L. McGovern (A), Terry J. Merritt (M), Robert H. Metzler (J), James O'Brien (A), James Earl Peterson (A), Franklyn Pinchbeck (J), Maurice W. Ramsby

New Members Qualified

Continued

(A), James Michael Roy (J), Franklin C. Schoonover (J), Jack C. Schram (J), Richard L. Schreiner (J), Edward Shell (J), Dewey V. Sherman (A), Walter W. Shuttleworth (J), John M. Skupin (J), George G. Spehn (M), Morris R. Steere (M), Janusz S. Sulich (J), John D. Van de Vuurst (J), Richard L. Vroman (M), Peter P. Wall (A), Frank J. Wanderski (J), T. W. Warren (M), Clinton C. Williams (J), Frank Wino (M), J. R. Worgan (J), Edwin L. Yates (A), Alexander Zaplitny, Jr. (J), Bruno Zava (M).

Hawaii Section

George A. Roth (M), J. Lowell Twidwell (A), William B. Walter (M), Roy E. Ward (M).

Indiana Section

Glenn W. Adamson (J), Thomas E. Battle (M).

Kansas City Section

John L. Koetting (M), Charles J. Tringali (J).

Metropolitan Section

Warren E. Begas (A), Gerald L. Berman (J), D. Gardner Foulke (M), Howard G. Kurtz, Jr. (A), Griffith May (M), Walter E. Miller (A), Leo V. Mullen, Jr. (M), Stuart B. Rote, Jr. (A), Walter I. Shanler (J), Arthur J. Taylor (M), Lionel E. Trotman (A), Peter Emmons Viemeister (M), Rudolph J. Zanella (J).

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Bill Mitacek (M), Willis C. Schickram (J).

Mid-Michigan Section

Lloyd T. Gill (M), Thomas W. Lamar (M).

Milwaukee Section

R. M. Brusewitz (M), James H. Carpenter, Jr. (J), Warren W. Schwid (M).

Mohawk-Hudson Section

John Gaylord Howe (J).

Montreal Section

Charles Peter Kirwan (M), Jean-Jacques Langlois (M), David L. Spanjer (M), P. J. Todkill (M).

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George P. Dinell (A), Woodrow W. (Bob) Foss (A), Philip F. Peterson (J).

Northern California Section

Folke H. Anderson (M), Eng Lan Foo (J), Demo John Giulianetti (J), H. Paul Kraus (M), Frank Mithen (A), Robert K. Stone (M), Robert E. Wilcox (J).

Northwest Section

Boyd K. Bucey (M), Leonids Maktenieks (J), Bruce V. Nylund (J), Edward A. Rock (M), William Stebbins (J).

Oregon Section

Arthur R. Darling (A), John A. Payne (A), Edward F. Vala (M), Kenneth Willoughby (A), Brock Byrne Wilson (J).

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New Members Qualified

Continued

Philadelphia Section

John J. Giammaria (M), Hilding R. Hultkrans (J), Noel S. Siegel (M), Charles N. Smith (M).

Pittsburgh Section

John F. Beck (M), Robert A. Bub (M), Edwin H. Spuhler (M).

St. Louis Section

Paul C. Ford (M), James Arthur Jones (J).

Salt Lake Group

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Southern New England Section

Manly E. Carroll, Jr. (J), Frederick F. Petrucci (J), Norman L. Zabilansky (J).

Spokane-Intermountain Section

Gordon Schuster (A).

Syracuse Section

Richard Anthony Crocco (J), Howard J. Dingman (J), Donald B. Jones (J), James E. Maroney (J).

Texas Section

Lew Brown Woodall (A), Roderick L. Zorn (A).

Texas Gulf Coast Section

Ralph C. Cooley, Jr. (A), John B. Milwee (A).

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New Members Qualified

Continued

Twin City Section

John M. Shank (M), W. R. Shannon (M).

Washington Section

Leon O. Brooks (M), Lt. Col. Sir Frederick G. L. Coates (M).

Western Michigan Section

Edwin A. McClary (A).

Wichita Section

Archie E. Campbell (M).

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Foreign

Antonio Barella (M), Brazil; John A. Black (J), Australia; Carlos Eugenio Borges Cortes (J), Brazil; Clifford Peter Brown (J), England; Willy A. Dahl (M), Brazil; Antonio Avelino Da Silva, Jr. (J), Portuguese West Africa; Leon Gattegno (M), Brazil; C. H. Henrard (M), Belgium; Ahmed A. Issa (A), Egypt; T. L. Narasimhan (M), India; Madhukar V. Vaidya (A), India.

Applications Received

The applications for membership received between January 10, 1957 and February 10, 1957 are listed below.

Alberta Group

Ralph Pogson.

British Columbia Section

James Scott.

continued on page 134

Applications Received

Continued

Buffalo Section

Wilbur W. Smith, Jr.

Canadian Section

Joseph L. Blais, Charles A. Hatchard, David Lloyd Jones, R. H. Mallory, Arthur Paulin, Gordon F. Ritz.

Central Illinois Section

Noble G. Barker, Glenn I. Bronstad, Harry E. Davis, Paul F. Dirksen, Robert J. Huebner, Peter W. Schultz, Fred M. Szabados, Jr., Donald F. Webster.

Chicago Section

Arthur R. Bonvouloir, Jeanie S. Christie, Joseph Demasy, Sidney Allen Heenan, C. Don Hicks, John Allen Holmes, Robert H. Klopp, Steven Malkowski, Russell J. Neff, Richard L. Nix, L. L. Duke Norman, Arlen E. Nyman, Arthur J. Peters, Ralph D. Webb, Ross D. Young.

Cincinnati Section

Paul H. Blessing, Carl Weider.

Cleveland Section

Joseph R. Teagno, Phyllis P. Whalen.

Colorado Group

George Myron Jones.

Dayton Section

Duke Dinsmore, John Dean Kiner, Howard R. Otto.

Detroit Section

Henry J. Baecker, Frederick P. Bens, Hugh J. Blecki, Andrew Buffa, Robert S. Cliffton, Theodore F. Cohassey, John K. Dobbyn, Perry C. Dooley, Wilbur L. Frayer, Earle Harvey Fulford, D. E. Garrison, Wesley S. Harjala, Roy C. Harrison, Gerald F. Hause, Charles I. Hodgson, Paul F. Hood, Leo Francis Kasaczun, Christopher M. Kennedy, Luther N. Kern, Wynne R. Lilly, Edward Mark, William Henry McGrow, Kuldip Mehta, James M. Miskimins, Sarv D. S. Mongia, Robert D. Neuharth, Fred Karl Nothdurft, Richard

Applications Received

Continued

J. Omalaske, Joe M. Ouellette, Donald B. Pentecost, Owen C. Russell, Vincent Ryszewski, William J. Schrader, Joseph H. Schultz, George Seidman, Ben J. Smith, Louis P. Smith, Marcus Claude Smith, Kenneth John Templin, Charles H. Thomas, Harvey E. Wortz.

Indiana Section

William Gene Andrews, Edmund A. Burroughs, Robert E. Hoffmeister, Robert J. Muelhausen.

Kansas City Section

James Frank Burdett, Charles C. Cochran, Jr., Anthony E. Cocoros, John G. Matalon, H. E. Mathews.

Metropolitan Section

Robert E. Barnum, Robert L. Burke, Robert J. Conable, Francis H. Eipper, Louis E. Gaynor, Frederick E. Graves, John D. Griffin, J. A. McCanney, Philip S. Rust, William B. Smyth, James J. Studenic, Paul V. Wagner, Joseph Wechter.

Mid-Michigan Section

John G. Arnold, Albert Betzler, Jr., Alexander Bleshenski, Dennis E. Condon, Thomas E. Darnton, William S. Hayes, Thomas J. Krieg, Joseph P. McGrail, Donald C. Ruschman, Carroll C. Seelye, George B. Whitesell.

Milwaukee Section

Albert E. Buchholz, Jr., Richard A. Burkard, Bruce Deyo, Clyde A. Fergason, Raymond E. Hren, Wallace E. Johnson, Don F. Kueny, Clarence R. Martin, Donald Keith Stephenson.

Montreal Section

Edward L. Switzer.

New England Section

Dr. Saul Barron, Frank W. Fernald.

Northern California Section

George R. Cunnington, Jr., Walter J. Frisch.

Northwest Section

John J. Shorkey.

Oregon Section

Arthur F. Dickow.

Philadelphia Section

Robert Bruce Koch, Donald C. Rowe.

Salt Lake Group

Donald J. Balka.

San Diego Section

Donald M. McGrath.

Southern California Section

E. M. Armstrong, Edward M. Brodersen, Edwin M. Couleur, Malcolm Lee Fickel, Thomas R. Fisher, Jack F. Harrington, Joseph E. Havenner, Dennis E. Mellen, Joseph A. Palm, L. D. Shafer, Joseph J. Struck, Earl S. Suters, Jr., T. A. Wilmshurst.

Southern New England Section

Richard Bell, George Paul Harrington, Jr., Peter F. Nizen.

Spokane-Intermountain Section

Elmer C. Lindahl.

Texas Section

J. W. Ferris, Jr., C. L. Harris, Marion R. Rue, Hale W. Stevenson, Ralph R. Uhrmacher.

Twin City Section

Louis B. Evans, Thiel E. Knoertzer.

Washington Section

S. Arthur Casale, Lawrence D. Reimer, Jr., Alvin Joseph Tolbert.

Wichita Section

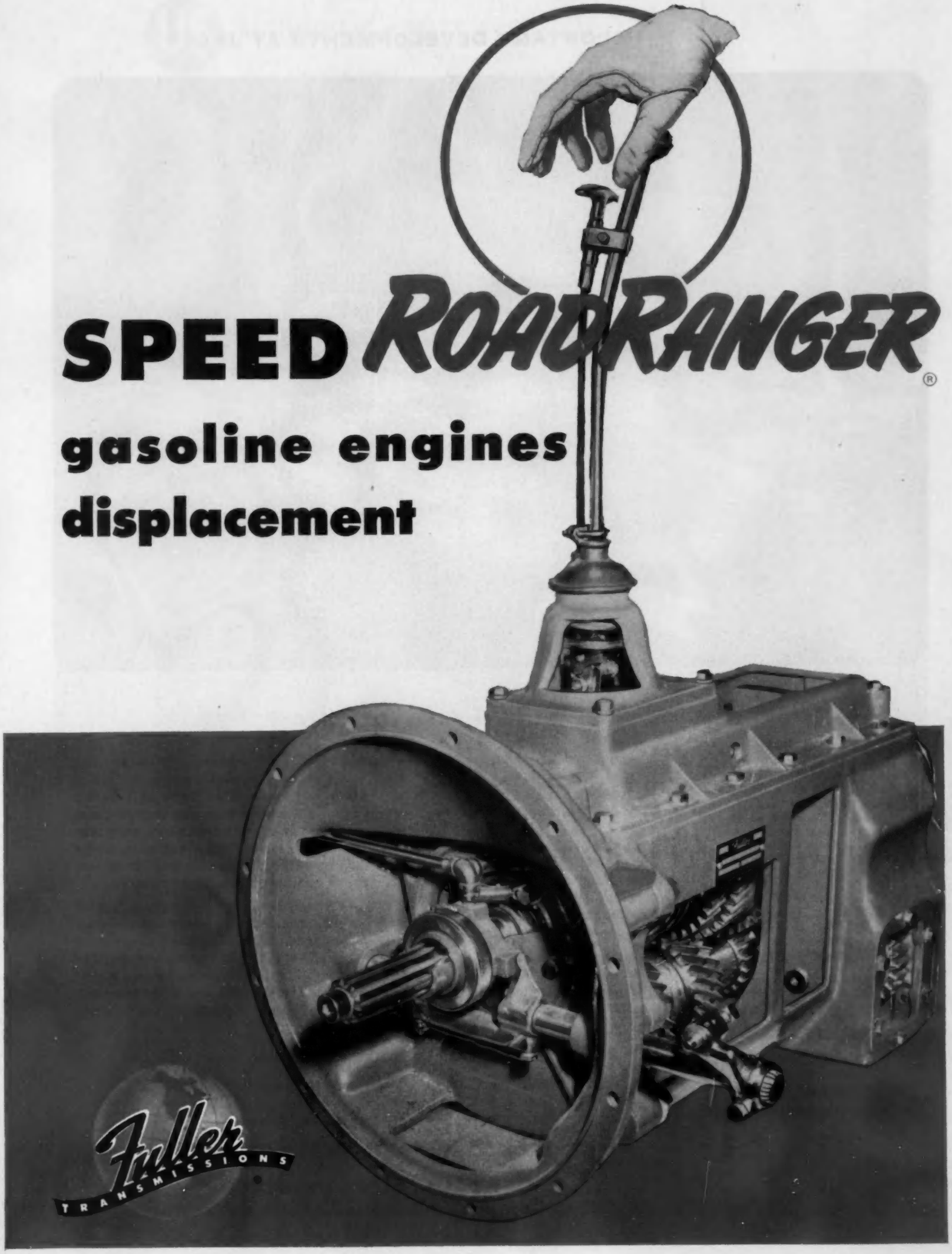
Wendell E. Miller.

Outside of Section Territory

Edward Drott, Jr., Joseph T. Ream, Jr., Eugene E. Richards, Ludwig J. Schinnerer.

Foreign

Svante Rune K. Breitz, Sweden; George Alexis Bronder, Australia; Hans Weber, Switzerland.



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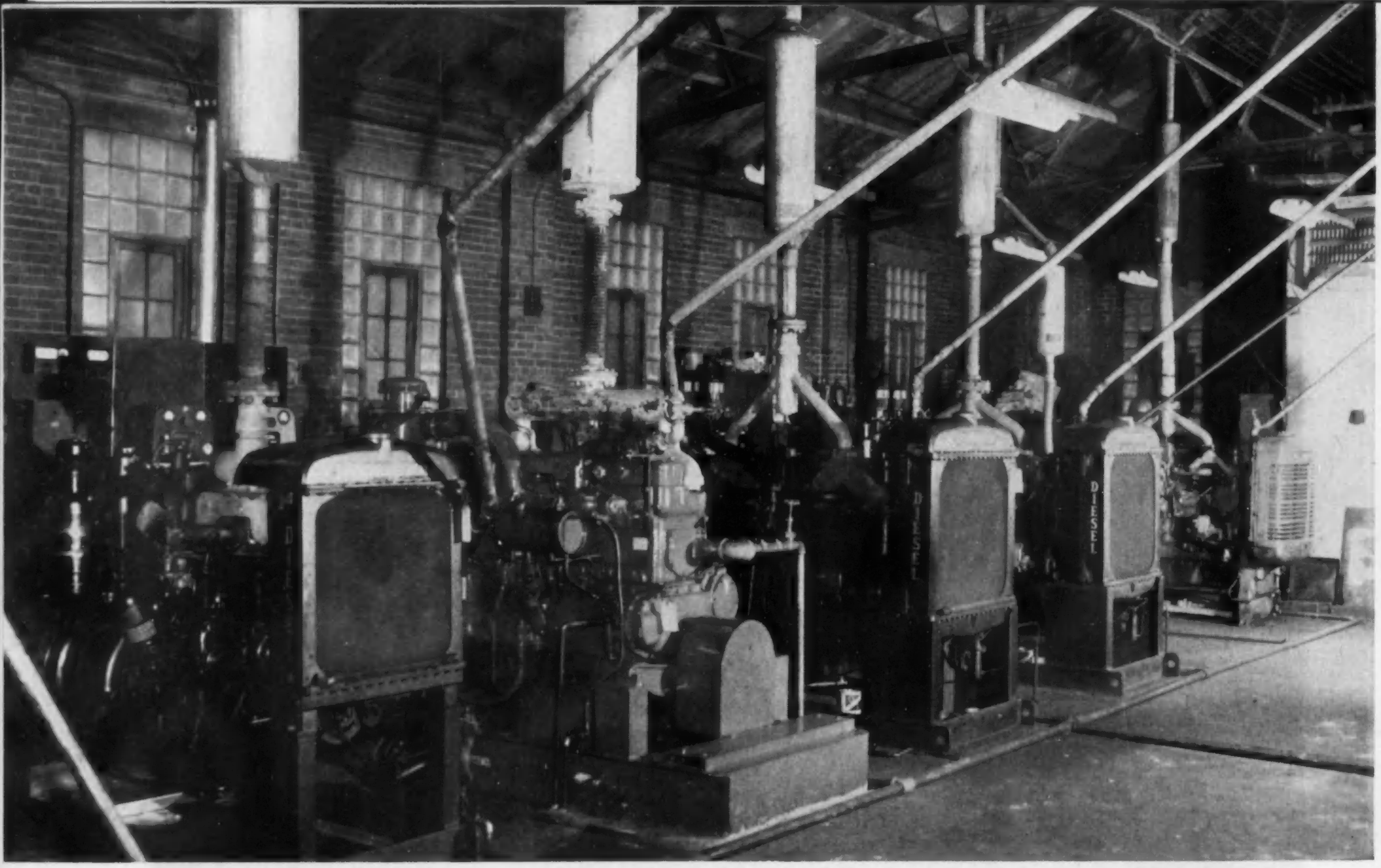


Here are five of eight International diesels that have driven Ready-Power generators in Standard Carbon's powerhouse for a total of 107 engine service-years. The UD-1091, second from left, is seven months old. The other 7 power units average over 15 years each of dependable service.

8 Ready-Power International driven GENERATORS CUT ELECTRIC COSTS 43%

Standard Carbon's International power units going strong after 107 service-years

The Standard Carbon Co., Steubenville, Ohio, is a nationally famous manufacturer of carbon brushes.

President W. F. Rogers fills in these details of their powerhouse operation: "We started in business in 1928 operating on purchased power. Back in 1939 we set up our own powerhouse—starting with an International PD-80 diesel power unit on a 48KW Ready-Power generator. Shortly thereafter we bought two more of these units. Today our eight Ready-Power generators are all driven by Internationals—*and we are generating power for 43% less than we pay for the 15% of the electricity we still purchase*."

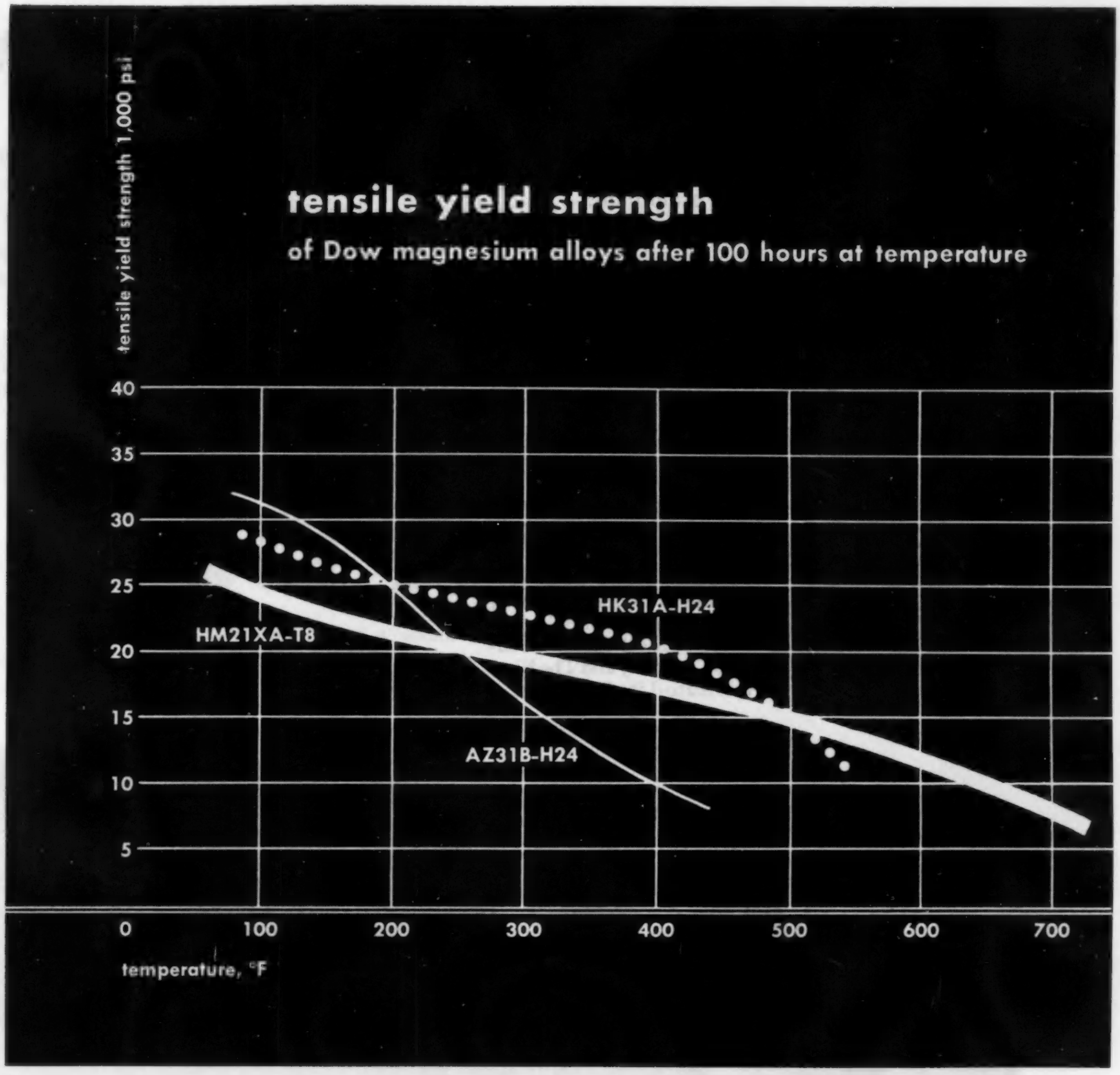
Supt. George Rogers adds: "Good service with only minor repairs sums up our experience with Internationals. Our Internationals have totalled 107 service-years—an average of over 13 years per engine. And only recently I rebuilt one of the 17-year-olds for the first time and still was able to reuse many of the original parts including the crankshaft!"

This long-life, low-cost power will help you protect the reputation of your products. Get it by specifying any of 16 International diesel or carbureted engines ranging up to 216 horsepower. Call or write us. Experienced sales representatives, sales and design engineers will assist you with product data and power recommendations that will help solve your engine problem. Then you'll have power that will increase the productivity of your products.

INTERNATIONAL® CONSTRUCTION EQUIPMENT

International Harvester Company
180 N. Michigan Ave., Chicago 1, Illinois

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors ... Self-Propelled Scrapers and Bottom-Dumps ... Crawler and Rubber-Tired Loaders ... Off-Highway Trucks ... Diesel and Carbureted Engines ... Motor Trucks



New magnesium alloy holds properties for 100 hours up to 700°F.

Dow Magnesium HM21XA-T8 alloy extends further the range of conditions under which light metals can be used in aircraft design. Second in the series of sheet alloys designed specifically for elevated temperature applications, it supplements the excellent characteristics of HK31A alloy.

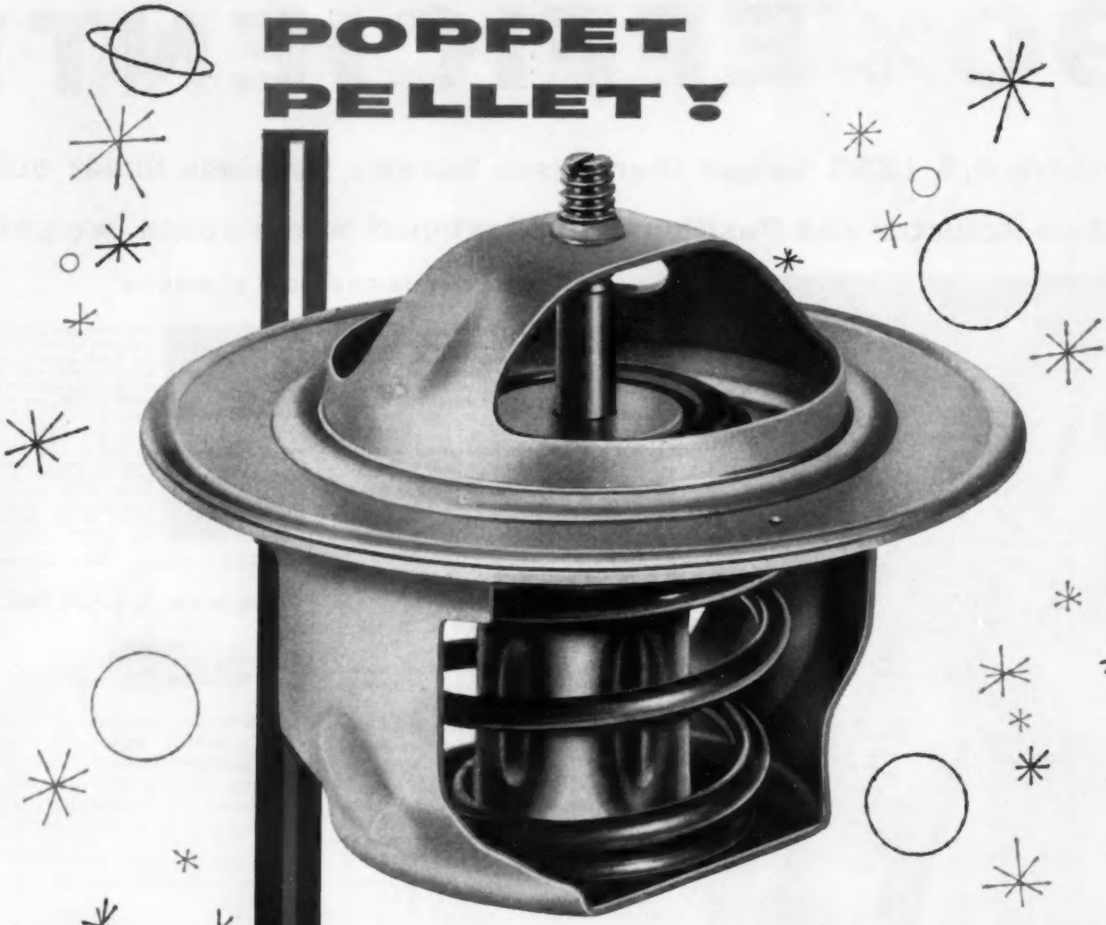
HM21XA-T8 retains its properties at temperature during long periods of time. Even one hundred hours at 700°F. results in relatively little change in tensile yield, creep and elastic modulus.

Magnesium lightness is combined with strength at elevated temperature in HM21XA-T8, offering new ways to save weight or gain increased rigidity in the design of missiles and aircraft. This alloy is supplied in the -T8 temper and can be formed in this temper without the need for further heat treatment after fabricating. Samples of HM21XA-T8 along with detailed information are available. Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1400D-1.

YOU CAN DEPEND ON DOW

Now from the maker of more than 100,000,000 thermostats

NEW HARRISON POPPET PELLET!



Designed specifically for today's high-pressure cooling systems!

Harrison's new poppet pellet thermostat brings all the advantages of the conventional pellet-type stat *plus* a revolutionary reverse-action valve feature which permits a more uniform, free flow of water. And with no soldered joints and no hinges, this new Harrison thermostat gives extra-rugged, extra-dependable service—assures accurate temperature control for modern high-compression engines under the most severe operating conditions. This is typical of the many advances made by Harrison, maker of over 100,000,000 thermostats. For *temperature is our business* at Harrison—and we're constantly seeking *and finding* new and improved ways to meet the heat control challenges of the automotive industry.

Watch WIDE WIDE WORLD Sundays on NBC-TV

GM GENERAL MOTORS

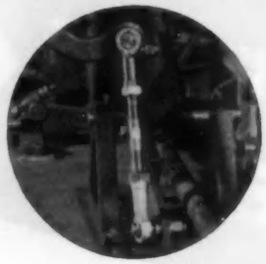
TEMPERATURES MADE TO ORDER

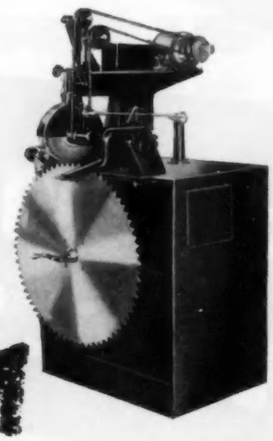
HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

These applications demonstrate the self-aligning ability of the HEIM Unibal

This linkage controls the shuttle motion of the label loom made by Fletcher Works of Philadelphia. This application visually demonstrates the ease with which misalignment can be corrected.





On this Armstrong Sharpener, which handles saws up to 120" in diameter, the push-pull rod with a Heim Unibal Rod End at each end, provides the universal motion for changing direction of the grinding wheel smoothly, quietly, and with precision for extreme sensitivity in grinding fine teeth.

Where shaft misalignment must be corrected . . .

The HEIM *Unibal* ROD END

is a single ball rotating in a bronze bearing race. It offers freedom of movement such as cannot be obtained with any similar mechanism. As a self-aligning bearing, it compensates for designed or unavoidable shaft or stud misalignment. Because of the large area of contact between the ball and the bronze bearing inserts, much greater load ratings are possible for substantially smaller envelope dimensions.

The Minneapolis Sewing Machine Co. uses Heim Unibal Rod Ends to take care of a 25° operating misalignment in the linkages in their model H-150 portable sewing machine.

Please feel free to write our engineering department about your linkage problems, and be sure you have sufficient copies of the Heim catalog for all designing, operating, and purchasing departments.

THE HEIM COMPANY / Fairfield, Connecticut

BRUTE STRENGTH FOR BIG ASSEMBLIES—

Cleveland large diameter upset forged socket head cap screws

On big presses, extrusion machinery, and earth moving equipment, fasteners not only have to support massive static loads; they must also withstand the dynamic stress of heavy impact, shock and vibration.

Engineered specifically for this type of service, Cleveland large diameter socket head cap screws are upset forged from specially heat-treated alloy steel. The forging process shapes the steel so that grain flow follows the contour of the head; eliminates planes of weakness along which shear might occur under dynamic stress; and protects assemblies against fastener fatigue failure.

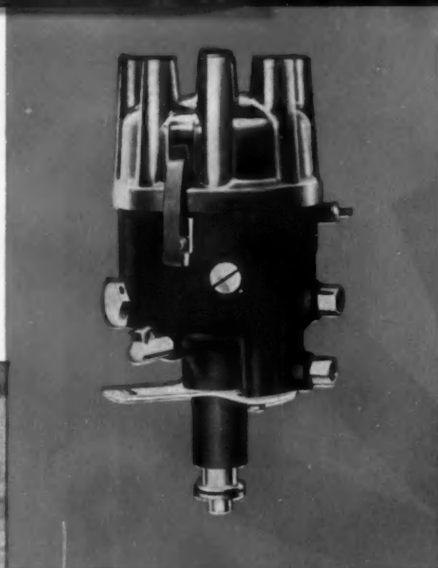
In large diameters we regularly stock 1¼-7 and 1½-6 through 12 in. for same-day shipment. For other standard sizes from 1⅛ to 3 in. diameter through 12 in. length, we have the stock and the tooling to produce your order quickly.* For prompt service, contact your local Cleveland distributor. He can also supply large diameter upset forged hexagon head cap screws.

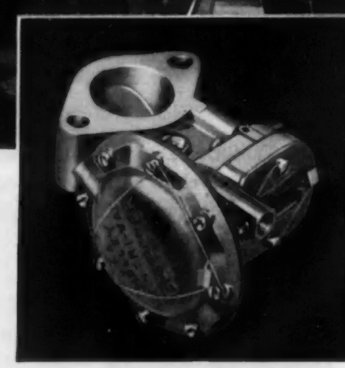
*Diameters over 3 in., lengths over 12 in., available on special order.

New folder gives dimensions (including old and new head details), physical properties, weights, prices of Cleveland large diameter socket head cap screws. Write for copy today.

THE CLEVELAND CAP SCREW COMPANY
4444-12 Lee Road, Cleveland 28, Ohio
WAREHOUSES: Chicago • Philadelphia • New York • Providence • Los Angeles

'57 Dodge Truck engine to use newly-designed Holley Distributor





First installation of the Rotovance Distributor (above) and Holley Governor (at right) will be on 1957 Dodge Truck models equipped with 354 engines. Two governors are used when the 354 engine is equipped with dual carburetion.

The first basic distributor design change in over two decades – Holley's new Rotovance Distributor and sandwich governor assembly – is standard equipment on the 354 cu. in. Dodge Truck engine for 1957. This distributor-governor combination is the first to locate control valve and advance mechanisms in a single housing.

The Rotovance Distributor and governor systems provide positive, consistent engine speed control – without power loss – with much better regulation than ordinary governors, from cut off to load point. Also standard on all Dodge Trucks equipped with Rotovance Distributors: Holley Ventilated Contact Sets. These unique center-vent points have proven in the laboratory and field alike to have a service life expectancy several times that of present contact sets.

See the new Holley Rotovance Distributor with sandwich governor at your nearby Dodge Truck dealer. It's one of the many advanced-design features which help give new "K" Series Dodge Trucks greater power and increased engine performance for 1957.

HOLLEY
Carburetor Co.

11955 E. NINE MILE ROAD
VAN DYKE, MICHIGAN

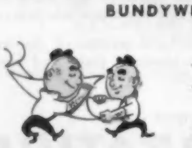
FOR MORE THAN HALF-A-CENTURY—
ORIGINAL EQUIPMENT MANUFACTURERS
FOR THE AUTOMOTIVE INDUSTRY

Bundyweld Tubing guides and guards

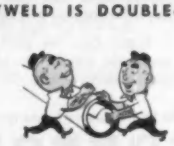
Above, six-way power seat on the 1957 De Soto.

In 1957 Imperials, Chryslers, De Sotos, and Dodges, fingertip pressure on the master switch sends Ferro's new power seat adjuster into action. Solenoids engage the proper selective drive; rotating cables transmit torque from electric motor to synchronized slave units in each track. Seat moves up, down, forward, backward; tilts up and forward, down and backward.

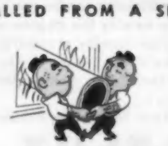
BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP



Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

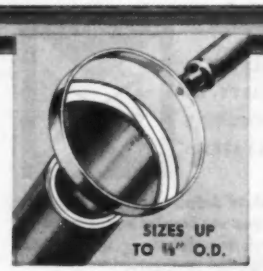


continuously rolled twice around, laterally into a tube of uniform thickness, and

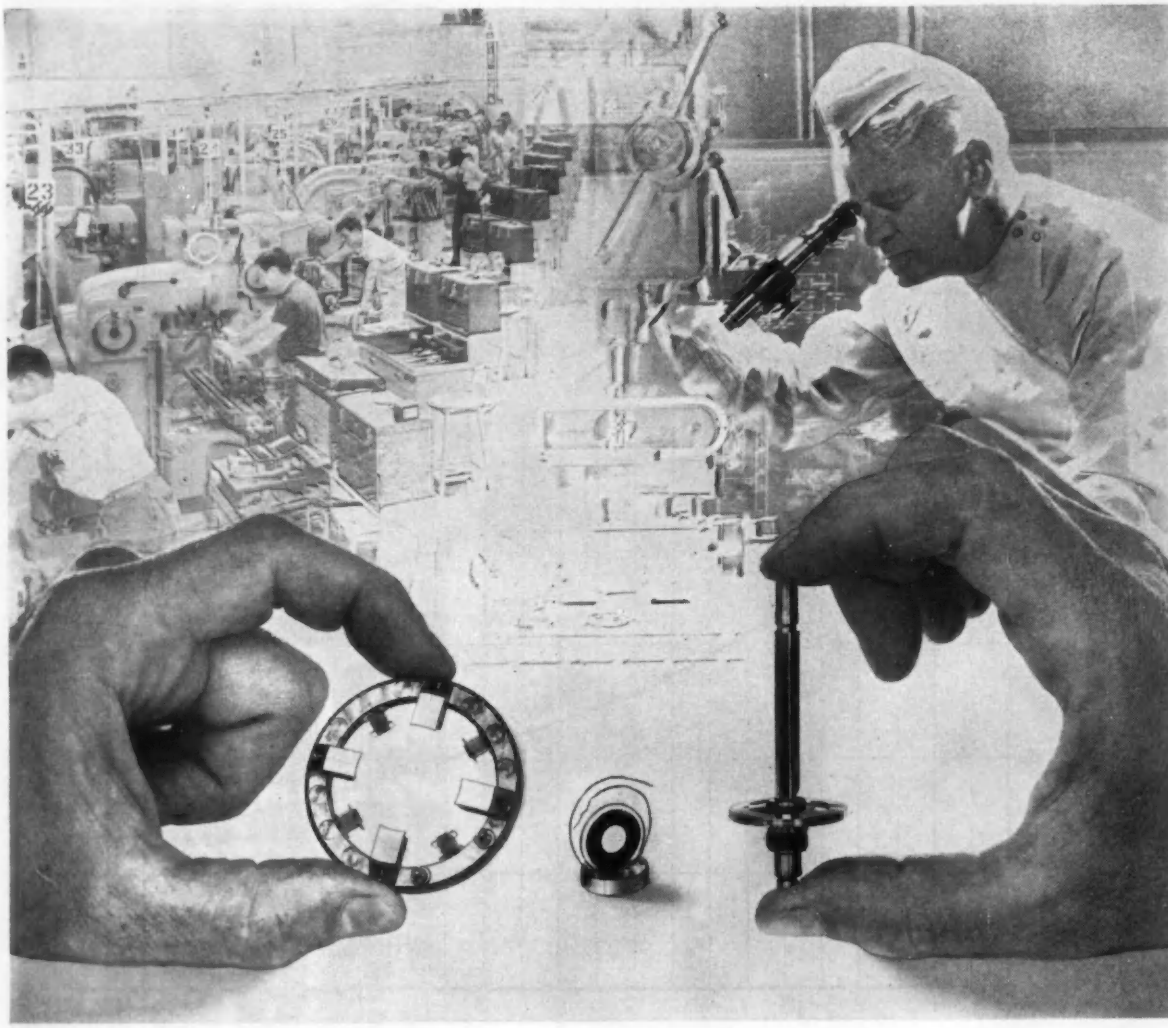


passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.



NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.



Autonetics brings laboratory precision to the production line

...with special tools and techniques

Side by side with its achievements in electro-mechanical *engineering*, AUTONETICS has developed laboratory-perfect *manufacturing* skills and equipment to turn intricate designs into complete guidance and control systems ... *in quantity*.

This unique production capability embraces almost every phase of advanced electro-mechanical technology. Precision machine shops — among the most complete in the country — contain special tools which have millionth-of-an-inch capabilities. Electronics production extends into the furthermost areas of microminiaturization, etched-transistorized circuitry and computer fabrication.

In fabrication and assembly of high precision equipment, AUTONETICS has reduced to a production science what was formerly regarded as work for the artisan.

To assure consistent compliance with rigid military specifications, AUTONETICS has developed extensive check-out equipment—ranging from completely automatic electronic test systems to specialized electro-hydraulic testing facilities.

With a wide variety of skilled engineers, manufacturing and supporting personnel, and modern facilities, AUTONETICS is one of the few companies in the world today with full capability in the design and quantity manufacture of inertial navigation, flight control and armament control systems, computers and other complete systems for the military and industry.

For detailed information—or for employment in this dynamic field — write: AUTONETICS, Dept. SAE-72, 12214 Lakewood Blvd., Downey, California.

Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC.

AUTOMATIC CONTROLS MAN HAS NEVER BUILT BEFORE

For high-integrity fluid lines specify R/M FLEXIBLE THIN-WALL Teflon* HOSE

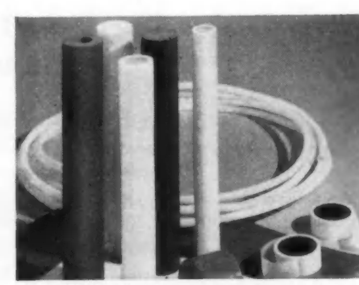
You can depend on R/M Flexible Thin-Wall "Teflon" Hose to withstand corrosive fluids, high mechanical stresses, and extreme ambient temperatures. In every application, it means an extra measure of safety and performance.

R/M's new hose — stainless steel wire-braided or rubber-covered — is extremely flexible and does not expand, contract or fatigue. It can be kept in continuous service at temperatures from –100° to +400°F, and is chemically inert to hydraulic fluids and synthetic lubricants. Also it has a very low coefficient of friction, reducing pressure drop in fluid systems to a minimum.

R/M Flexible Thin-Wall "Teflon" Hose is one of a large family of products developed by R/M engineers to take advantage of the unique properties of this material. Our long experience with "Teflon" is your best assurance of the highest quality.

This hose is available through leading coupling manufacturers. A list of suppliers and complete specifications will be furnished on request.

*A Du Pont trademark



Other R/M "Teflon" products for the automotive and aviation industries include rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; Raylon — a mechanical grade of "Teflon" having many of the properties of virgin "Teflon." For details, call or write R/M.

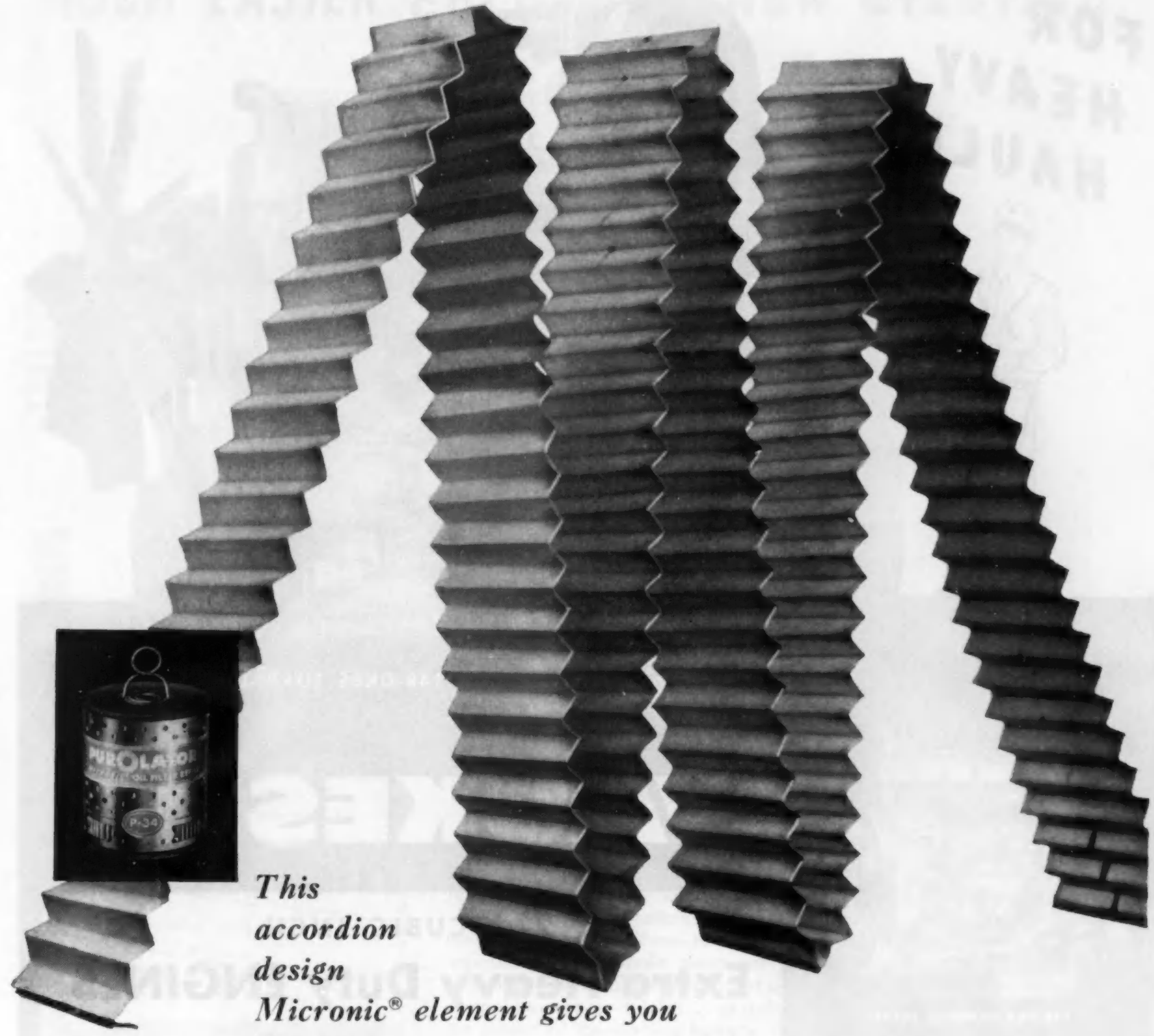
R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment
Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls



This accordion design Micronic® element gives you

10 times more filtration area for full engine protection

Pull out Purolator's accordion design and you'll see how Purolator packs 10 times more filtration area into its element than most filters. You'll find it provides maximum filtering area in minimum space, assuring *full* engine protection as no other filter does.

Controlled porosity of Purolator's Micronic® element filters out particles as small as .000039 of an inch, yet never removes costly additives in heavy-duty or detergent oils and never channels. The Micronic® element, made of plastic-impregnated cellulose, isn't affected by engine temperature, crankcase dilution, or water.

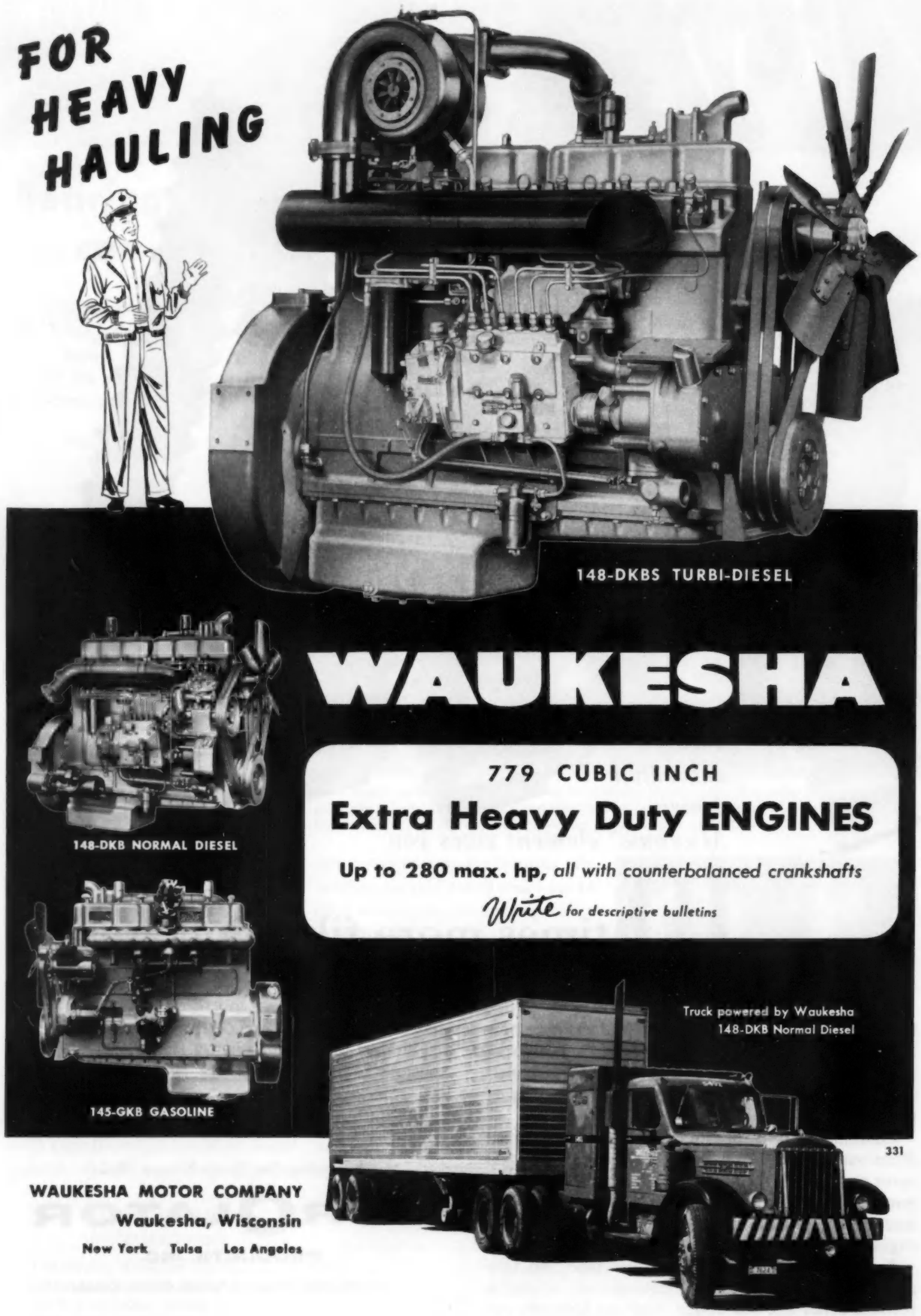
Engine manufacturers have proved time and time again that these wear-reducing features make an engine perform better and last longer. Find out how they can do the same job for you. Write for our new 32-page "Filtration Manual for Product Designers"—and please enclose 25¢ to cover postage and handling. Address Dept. A4-317.

Filtration For Every Known Fluid

PUROLATOR

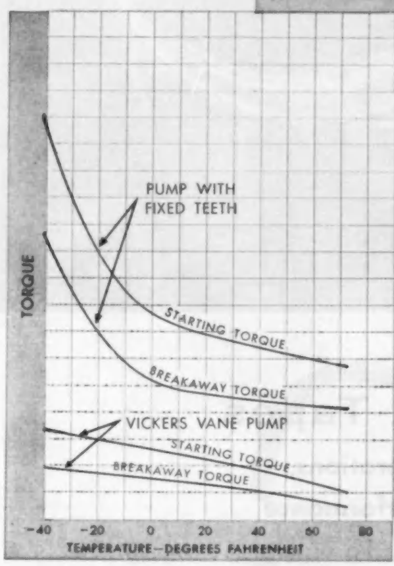
PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada


FOR HEAVY HAULING
148-DKBS TURBI-DIESEL
WAUKESHA
148-DKB NORMAL DIESEL
779 CUBIC INCH
Extra Heavy Duty ENGINES
Up to 280 max. hp, all with counterbalanced crankshafts
Write for descriptive bulletins
Truck powered by Waukesha
148-DKB Normal Diesel
145-GKB GASOLINE
331
WAUKESHA MOTOR COMPANY
Waukesha, Wisconsin
New York Tulsa Los Angeles

MUCH EASIER COLD WEATHER STARTING

Sno-Cat (without body) undergoing tests in extreme cold in the Pyrenees mountains preparatory to being used by French scientific expedition at the South Pole. Sno-Cats will also be used by the U.S. Navy and British Expeditions to the Antarctic.



Curves based on comparative tests of a Vickers Balanced Vane Type Pump and an equal-capacity pump with fixed teeth. Oil used in both was SAE 10W premium grade.

Another Reason Why

TUCKER SNO-CATS have

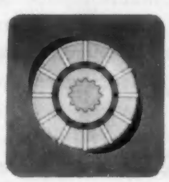
VICKERS® Balanced Vane Pumps

The Sno-Cat operates where it is really cold . . . high in the mountains . . . with U. S. Navy, French and British Expeditions in the bitter wastes of the Antarctic . . . wherever snow is so deep that wheel vehicles fail.

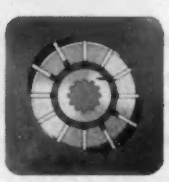
Like many other vehicles that must operate in cold weather, the Sno-Cat uses a Vickers Vane Pump to avoid the extra starting handicap that would be imposed by a hydraulic pump with fixed teeth or spring-extended vanes. In extremely low temperatures such a pump seriously increases starting load over normal (see curves at left) . . . at a time when the cold has substantially reduced the power of the starting battery. The diagrams below at the left show why Vickers Vane Pumps provide much easier cold weather starting.

All Tucker Sno-Cats use a Vickers hydraulic power steering system. In addition to the pump, these systems include a steering booster, a volume control, and overload relief valve.

Any vehicle which must operate in cold weather needs a hydraulic pump that provides "no-load starting". Let us tell you more about it . . . and about the many other reasons for using Vickers Balanced Vane Pumps.



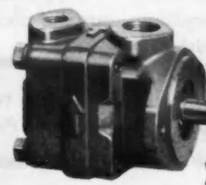
Schematic diagram of Vickers Balanced Vane Type Pump showing how sliding vanes are retracted at normal engine cranking speeds. No oil is pumped and there is practically no starting load.



Similar diagram shows how pump vanes are extended when engine fires. Pumping then begins and continues at all engine speeds (vanes are held in intimate contact with cam ring by system pressure in addition to centrifugal force).

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1440 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA • WASHINGTON • WORCESTER IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto



Vickers Balanced Vane Type Pumps for mobile equipment are available in five basic sizes having 15 normal delivery ratings and a variety of mountings. Other advantages include: high efficiency, automatic wear compensation, hydraulic balance, dependability and long life. Write for Catalog M-5101.

7376 *ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921*


SCHWITZER
CORPORATION
INDIANAPOLIS, INDIANA
Announces
Modulated Fan Drive
New Horsepower Saving
New Hushed Operation
New Increased Cooling
New Simplicity

MISSILES ENGINEERS...

Let's exchange resumes

NAME:
Douglas Aircraft Company, Inc.

POSITION:
World's largest manufacturer of aircraft and missile systems.

LOCATIONS:
Santa Monica, California
Naval Air Missiles Test Center
Point Mugu, California
Edwards Air Force Base, California
White Sands Proving Grounds
Las Cruces, New Mexico
Air Force Missiles Testing Center
Patrick Air Force Base
Cocoa, Florida
Holloman Air Development Center
Alamogordo, New Mexico

AGE:
15 years in missiles; 37 in aircraft.

EDUCATION:
An engineering company managed by engineers—such as Donald W. Douglas, B.S., Aeronautical Engineering (M.I.T.); F.W. Conant, B.S., Civil Engineering (Cornell); and A. E. Raymond, B.S., Mechanical Engineering (Harvard), M.S., Aeronautical Engineering (M.I.T.), and Ph.D. (Hon.) (Polytechnic Institute of Brooklyn)—and with key staff positions held by graduate engineers, physicists and mathematicians, many with advanced degrees.

EXPERIENCE:
Pioneers in missile research development and production since 1941.

Major contractors for air-to-surface, surface-to-surface, air-to-air and surface-to-air missile systems.

Designers of auxiliary equipment to transport and launch guided missiles.

Establishment of a completely separate missiles division in 1956.

Now responsibile for nine separate missile projects—including such "veterans" as Nike I (1945 to present) and Sparrow (1947 to present).

Extensive flight test experience at proving grounds across the country where Douglas engineers are assigned.

Missiles experience supplemented by 37 years in airframe design, development and manufacture.

REFERENCES:
The U.S. Army, Navy and Air Force.

Thousands of manufacturers of components for missile systems.

Some 1600 Douglas employees now engaged in missile work.

SPARROW I, the Navy's supersonic air-to-air guided missile, intercepts targets even under evasive action.

SERVO AMPLIFIERS used with a four-way electrohydraulic valve being tested by Douglas electronic engineer.

NAME:

POSITION:

ADDRESS:

AGE:

EDUCATION:

EXPERIENCE:

REFERENCES:

FILL IN THE ABOVE INFORMATION TEAR OUT THIS RESUME AND SEND TO
C. C. LaVENE
DOUGLAS AIRCRAFT COMPANY
BOX 620-O
SANTA MONICA, CALIFORNIA

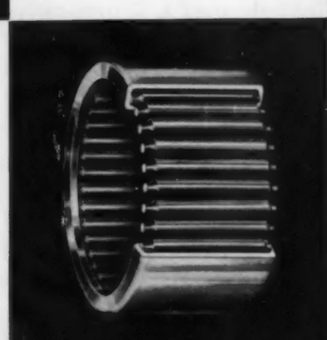
GO FURTHER WITH DOUGLAS FIRST IN AVIATION

IN TORTUOUS ALCOA TEST

...twenty-two tons hit a

TORRINGTON NEEDLE BEARINGS GIVE YOU THESE BENEFITS

- compactness and light weight
- unequaled radial load capacity
- low starting and running friction
- low unit cost
- run on hardened shafts
- allow larger and stiffer shafts



Many good turns a day!

Power steering has brought new ease and simplicity to driving. In power steering mechanisms, Torrington Needle Bearings have brought simplicity and economy of design, assembly and maintenance.

Especially preferred for this type of application, Needle Bearings offer unusual service dependability with a compactness unequaled by any other anti-friction bearing of comparable capacity. Compact in themselves, they also contribute to compact housing design and the use of larger, stronger shafts. They retain lubricant effectively, minimizing service requirements.

Such features have led to the use of Torrington Needle Bearings in a variety of automotive applications; transmissions, steering knuckles, brakes, clutches, hydraulic pumps and many others. For engineering assistance, talk to your Torrington representative. Catalog on request. THE TORRINGTON COMPANY, Torrington, Conn., South Bend 21, Ind.

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

BENDIX-WESTINGHOUSE AIR BRAKES

Best for original equipment because they're used by America's leading fleet operators!

Here's what **PACIFIC INTERMOUNTAIN EXPRESS** says about Air Brakes...

With headquarters in Oakland, California, P. I. E. has more than 3,000 pieces of mobile equipment in daily operation over 15,000 miles of scheduled routes. This modern, efficient fleet provides transcontinental shippers with dependable door-to-door motor freight service between the entire Pacific Coast and the midwestern gateways of Chicago, St. Louis, Kansas City and Wichita.

"During our 16 years in business

We've bought 6,000 trucks

AND WHEN IT COMES TO AIR BRAKES, WE USE

Bendix-Westinghouse!"

THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES

Here's what **R-C MOTOR LINES, INC.** says about Air Brakes...

With general offices in Jacksonville, Florida, R-C Motor Lines, Inc., provides fast, dependable express freight service to shippers along the eastern seaboard. The modern R-C fleet is comprised of over 500 rigs traveling interstate routes between 15 terminal points located in the states of New York, Pennsylvania, Maryland, Virginia, North and South Carolina, Georgia and Florida.

"During our 18 years in business

We've bought 1,000 trucks

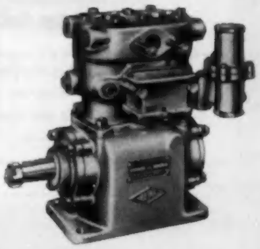
AND WHEN IT COMES TO AIR BRAKES, WE PREFER

Bendix-Westinghouse!"

THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES

It is a rarity indeed when a product in any field demonstrates customer use so strong that it continually *outsells all other competition combined* year after year. Yet, for the past twenty-five years this has been the remarkable accomplishment of Bendix-Westinghouse Air Brakes in the truck and bus fields! In fact, recognition of the greater safety, economy and dependability of Bendix-Westinghouse Air Brakes by truck buyers has resulted in their factory installation on more and more truck models of all sizes.

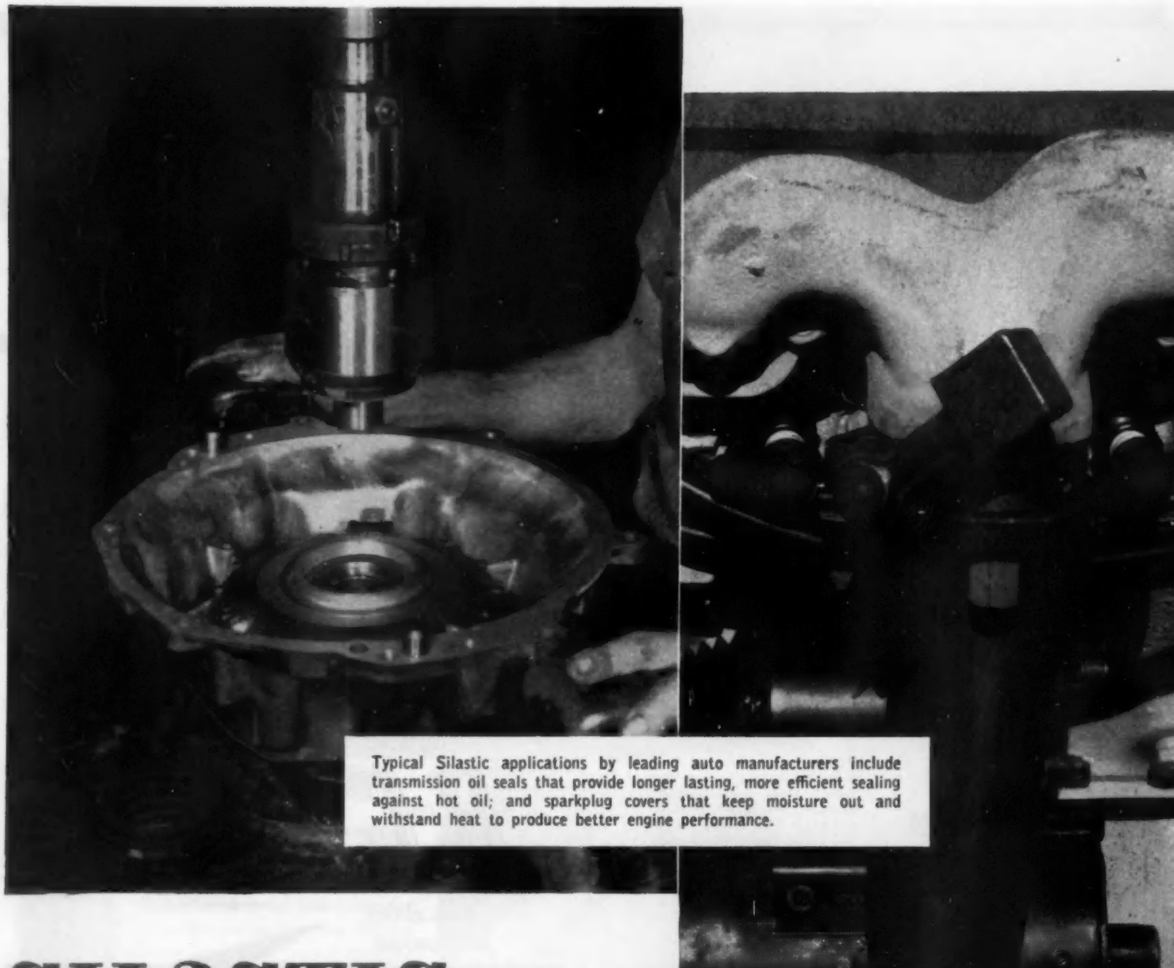
Chances are good that your trucks, too, offer the many advantages of these powerful brakes. If not, we suggest you take advantage of the proven superiority of Bendix-Westinghouse Air Brakes by offering them as factory-installed equipment. It's one sure and easy way to add more sales appeal to your vehicles!



Over 1,500,000 compressors, produced over a twenty-five-year span, stand behind the TU-FLO 400. Many advanced features guarantee performance no other compressor can equal.

Bendix-Westinghouse AIR BRAKES

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • General offices and factory—Elyria, Ohio. • Branches—Berkeley, Calif. and Oklahoma City, Okla.



Typical Silastic applications by leading auto manufacturers include transmission oil seals that provide longer lasting, more efficient sealing against hot oil; and sparkplug covers that keep moisture out and withstand heat to produce better engine performance.

SILASTIC molded parts seal oil in, moisture out

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Molded parts of Silastic*, Dow Corning's silicone rubber, show little or no change in physical or dielectric properties after long exposure to temperature extremes which would quickly ruin organic rubber. Leading rubber companies fabricate Silastic molded parts in practically any color, size or shape.

Typical Properties of Silastic for Molded Parts

• Temperature Range, °F	–130 to 500
• Tensile strength, psi	600 to 900
• Elongation, %	150 to 300
• Compression set, %, @ 300 F	15 to 40
• Hardness range, durometer	20 to 90
• Dielectric strength, volts/mil	400 to 500
• Oil resistance	Dependent on type of oil

If you consider ALL the properties of a silicone rubber, you'll specify SILASTIC.

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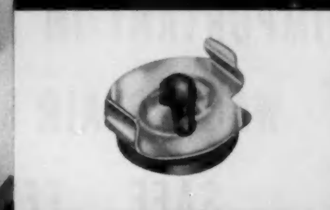
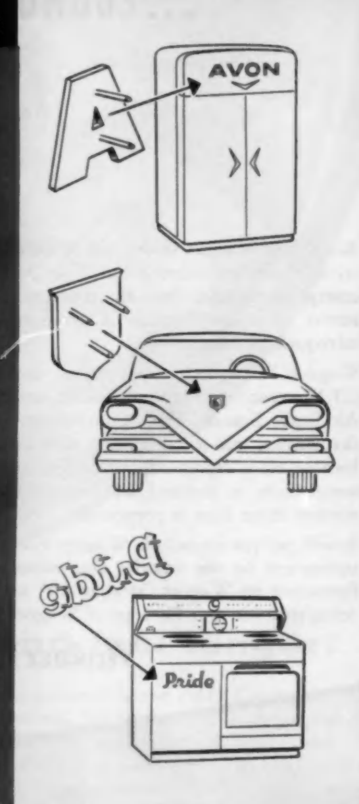
- Self-Locking
- Vibration-Proof
- Spring Take-Up





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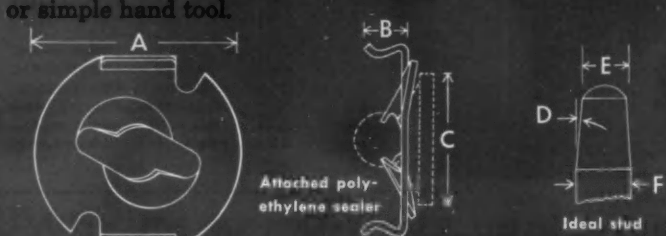
It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. When used with its preassembled plastic sealer, T.C.F. makes a water-tight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity*, with or without sealer, to fit 1/8" and 3/16" studs. Drawings available on request for magnetic tool or simple hand tool.



Nominal Sizes	A	B	C	D	E	F	Driving Torque	Ultimate Strength
1/8"	.560	.170	.450	6°/4°	.095 .085	.130 .125	7-10 Inch lbs.	200 lbs.
3/16"	.705	.200	.450	6°/3°	.160 .150	.192 .184	20 - 30 Inch lbs.	400 lbs.

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San Leandro, Cal.

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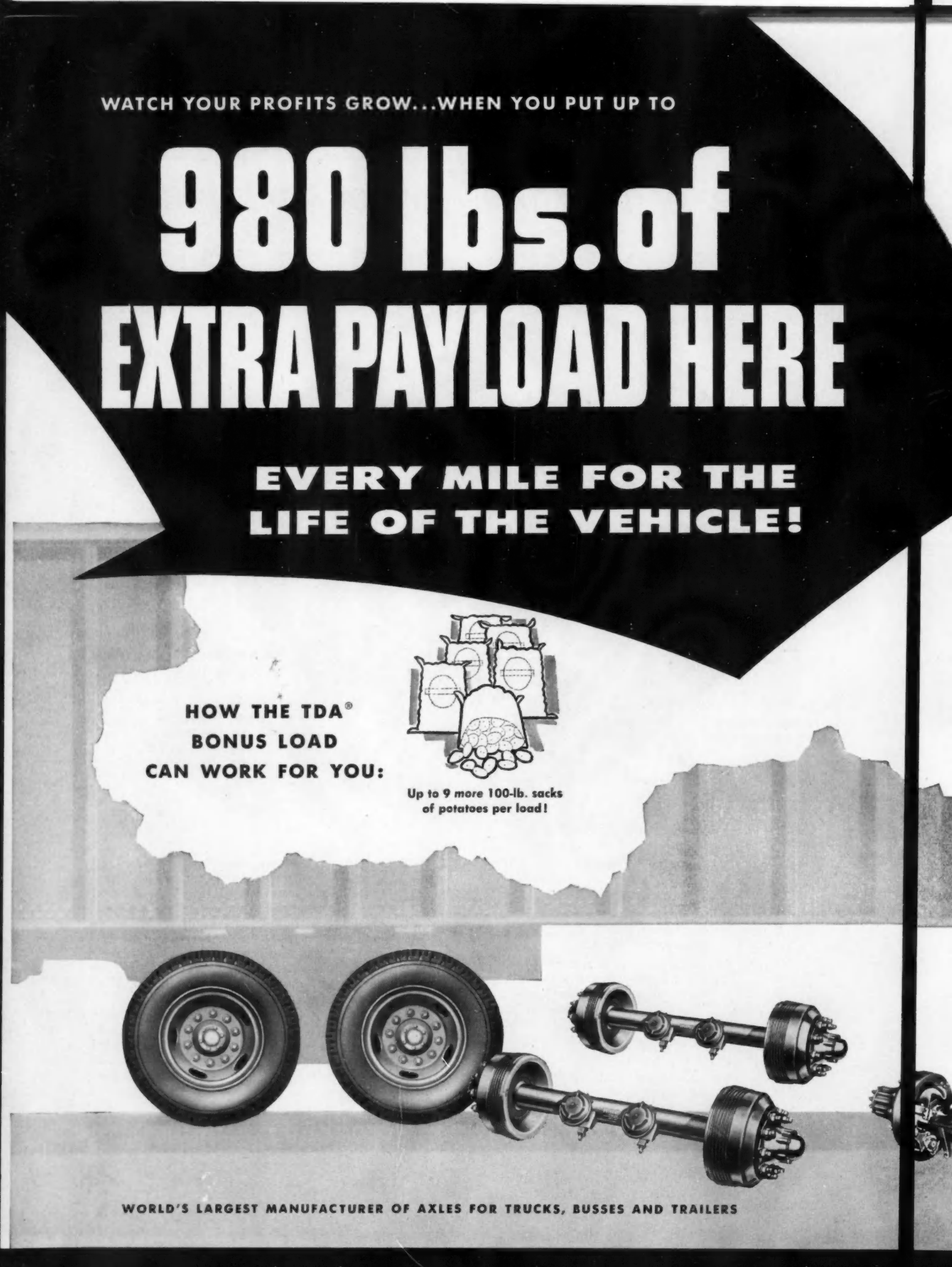
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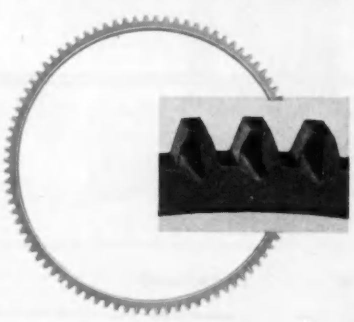

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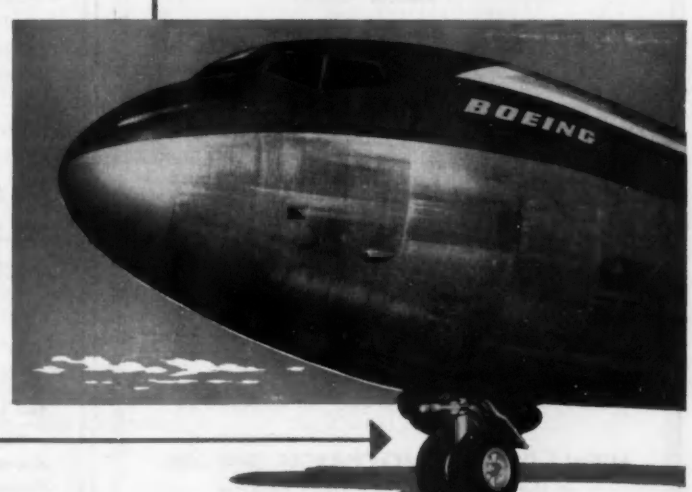
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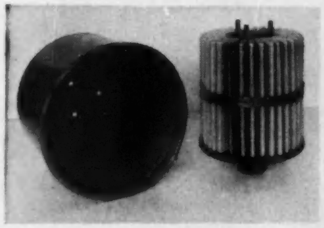

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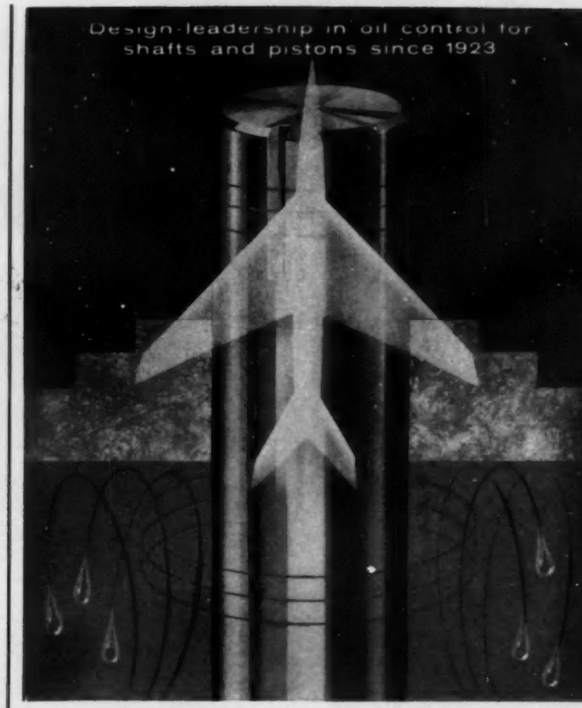

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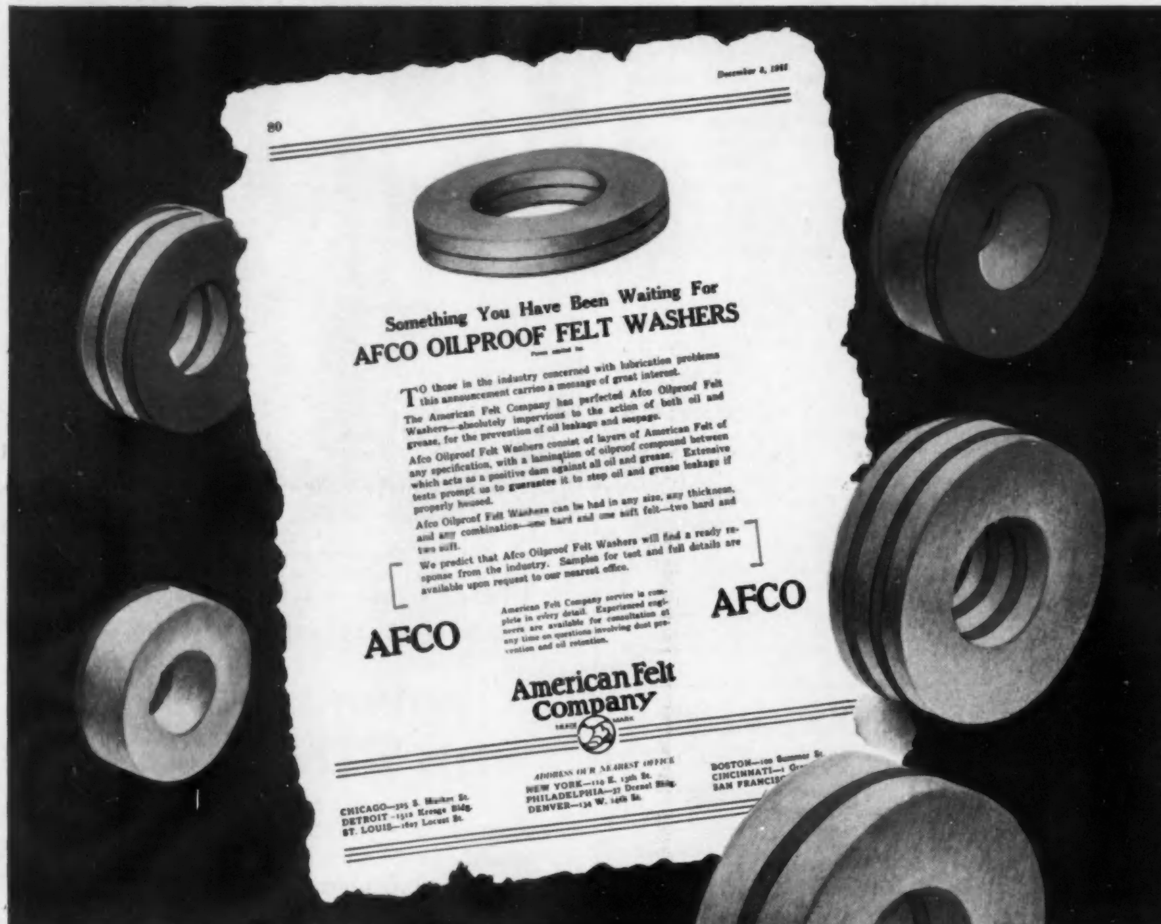

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